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ANATOMY OF THE PROTOXYLEM ELEMENTS OF SEVERAL SELAGINELLA SPECIES *

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FIVE PLATES

INTRODUCTION

A considerable amount of published literature has accrued on the morphology and anatomy of *Selaginella* species. Existing accounts on the anatomy of the stem pertain to developmental and descriptive studies of the different tissues of the stele and the factors determining the size and morphology of the vascular system. Cusick,(16) however, states that the protoxylem component of the vascular tissues has not been studied in detail.

Considerable diversity of organization of the vascular cylinder is characteristic of *Selaginella.* The vascular system of the stem is strikingly variable within the genus, ranging from simple protostele to "siphonostele." Harvey-Gibson(33) grouped the species which he studied into six-type forms, thus:

1. *Martensii* type: with dorsiventral axis and banded stele.
2. *Oregana* type: with homophyllous leaves but with banded stele.
3. *Anomalous monostelic* type: with two stelar ribbons in the rhizome, banded stele with ventral cord in the erect shoot.
4. *Galeottei* type: regularly bistelic.
5. *Inaequalifolia* type: with three or more parallel stelar bands.
6. *Lyallii* type: with solenostelic rhizome.

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In spite of this diversity of stelar organization, all members of the genus have certain features in common. They all have homogeneous xylem surrounded by parenchyma, phloem, and pericycle. Except in those cases where it is very small, the stele is in the form of a thin ribbon. This is true not only for the greater number of species which are definitely dorsiventral but also for radial homophyllous species.

The anatomy and histology of the stem is well known by botanists. This is reflected by the numerous references appearing in the literature [Barclay,(7) Cusick,(16,17) Dangeard,(18) Duerden,(19) Harvey-Gibson,(33) Hsu,(35) Jacobs,(36) Russow,(46) Spring,(51) Steel,(52) Wardlaw,(56) Williams,(59)]. Many accounts of its structure are given in standard textbooks [Eames,(21) Smith,(50) and others] in which the general topography of the vascular tissues is indicated, but in which only incidental observations concerning the anatomical features of the protoxylem elements have been recorded without any apparent attempt to demonstrate the actual structure of such elements.

When the protoxylem elements are studied in detail some structural differences may be observed among the different species. Here, then, is the purpose of the present investigation: to study, from the comparative point of view, the anatomy of the protoxylem components of the primary xylem of *Selaginella* species. Comparison is made on the basis of the following anatomical categories: (*1*) number of protoxylem points, (*2*) order of development of the primary xylem, (*3*) cell types and their wall sculpturing, (*4*) order of transition of cells, (*5*) number of helices in helical elements, and (*6*) direction of wall deposition of the helical elements.

MATERIALS AND METHODS

The materials used in this investigation consisted of four exotic species collected from stock cultures growing prolifically in moist pots in the greenhouse of the Horticulture Division, Department of Agronomy, Cornell University, Ithaca, New York, U.S.A., and three native species, which constituted part of the collection of Professor D. W. Bierhorst and which were very kindly placed at the disposal of the writer for this work.

No preference was exercised in the selection of the species worked upon in this investigation. The species investigated were simply the ones available at the time.

The greenhouse species were *S. martensii* Spring, from Mexico, *S. uncinata* Spring, from China; *S. kraussiana* (Kunze) A. Br., whose place of origin is traced to Cape Colony, Natal, Fernando Po, the Cameroon Mountains, Azores, Madeira, and Sicily [Baker,(6)]; and *S. braunii* Baker, from Western China.

The native species were *S. apoda* (L.) Fernald (*S. apus* Spring); *S. selaginoides* (L.) Link., and *S. rupestris* (L.) Spring. *S. apoda* and *S. selaginoides* were collected in September, 1956, from the east shore of Lake Huron, thirty miles of Tobermory, Ontario, Canada. The former was found growing on sand and limestone along the shoreline, and the latter in shady, boggy areas, a short distance within the woods from the shoreline. *S. rupestris* from Minnesota, was collected in 1951.

Preliminary data such as authentic establishment of identification of the species, etc., were taken by visual inspection and microscopic examination. Baker's (6) handbook was used for this purpose; however, other pertinent references as those of Brown,(11) Clausen,(12) Clute,(13, 14) Eseltine, (27) Friesner,(29) Greene,(30) Harper,(32) Hieronymous,(34) Tryon,(53, 54) Underwood,(55) Weathery,(57, 58) and others, were also frequently consulted to insure the proper identity of the individual species.

Samples were taken from a certain level of the stem and in every case from the main axis at two positions, each sample measuring approximately one centimeter in length. In the species with trailing stems, one sample was taken from the prostrate portion approximately two centimeters above the basal portion (ground level) and another from the tip portion, approximately two centimeters below the shoot apex.

Each sample was separately fixed and killed in formalin-propiono-alcohol in the following proportions: 50 per cent ethyl alcohol, 90 cc; propionic acid, 5 cc; and formalin, 5 cc. Each sample was assigned its own number to avoid confusion. The use of an aspirator aided rapid penetration of the tissues. The samples were washed in running water for several hours, passed through a series of dehydrating alcohols containing tertiary butyl alcohol and others in the proportion given by Johansen.(38) They were then embedded in paraffin. Prior to microtoming, however, one end of each piece of material was exposed to a softening solution of a mixture of 10 cc glycerine

and 90 cc of 70 per cent ethyl alcohol for about two weeks for the softer portions and longer for the more resistant pieces.

Sections were cut on a rotary microtome. For comparative purposes a thickness of 11 microns was used throughout the study. Very little difficulty was experienced in making transverse sections of the material but thin longitudinal sections were much harder to accomplish without occasional displacement or springing apart of the walls, even after the softening treatment.

Slides were prepared following the usual safranin-fast green and safranin-aniline blue stain schedules suggested by Johansen.(38) As many slides as the writer thought were practicable were prepared for authentic confirmation of his preliminary observations. No consideration is given to the tissues external to the vascular strands.

Illustrations were prepared from suitable sections with the aid of the camera lucida.

ANALYSIS OF THE PROTOXYLEM ELEMENTS

The study of the cell types, their wall sculpturing, order of transition of the protoxylem elements, the number of helices in helical elements, and the direction of deposition of the helices was based on the critical examination of longitudinal sections. Transverse sections were used in determining the number of protoxylem groups in the primary xylem. For the determination of the xylem type, whether exarch or mesarch, both transverse and longitudinal sections proved useful. Points of reference which have been taken into consideration in determining the order of development of the xylem are the position of the earliest-formed protoxylem cells in relation to the later-formed protoxylem cells and to the metaxylem elements, the character of the secondary wall thickenings of the protoxylem elements as seen in longitudinal sections, and where present, the position of the protoxylem lacunae in relation to the metaxylem elements in transverse views.

The terms "protoxylem" and "metaxylem" are used here as defined repeatedly by Esau (24, 25, 26) on the basis of the ontogenetic relationships of the portions of the primary xylem to the organ as a whole. This concept, which was originally introduced by Russow,(46) designates the protoxylem as the

xylem component that appears at the beginning of vascular differentiation and occupies a characteristic position in the primary vascular skeleton in a given plant organ. The location of these protoxylem cells, therefore, definitely marks the pattern of differentiation which is followed by subsequently appearing primary xylem, the metaxylem. This pattern varies depending on the plant group or type of organ, such that plants and organs could be classified on the basis of xylem development, whether exarch, mesarch, or endarch. Esau remarked that this concept of protoxylem proved very useful with regard to such classification in both vascular cryptogams and phanerogams.

In describing the microscopic characteristics of the protoxylem elements, the writer has, for convenience, adopted the nomenclature for the stelar cylinder given by Harvey-Gibson(33) in the grouping of the species investigated in this paper. No consideration is given to the anatomical features of the metaxylem elements.

MARTENSII TYPE

S. martensii.—The protostele is simple and ribbonlike in shape (Plate 1), which according to Harvey–Gibson,(33) runs throughout the axis of the plant.

The number of protoxylem groups varies from four to as many as six. Where four protoxylem groups occur, two are found at each marginal end of the flattened vascular bundle; when five are present, four are found at the margins and the fifth occurs on a dorsal strand situated midway between the marginal ends. And where there are six (Plate 1), four occupy marginal positions and the other two in small dorsally projecting xylem ridge situated midway between the marginal points.

The protoxylem consists of cells with annular, "transitional," and continuous helical secondary wall thickenings. (Plate 5, figs. 1, 2, 3, 4, 10, 11)

Only one helix is present in one helical element, rarely two.

Xylem development is decidedly mesarch but in some cases, may be more appropriately described as weakly mesarch (Plate 1). Eames and MacDaniels,(22) however, state that where development is such that both centripetal and centrifugal xylem are formed even though the amount of one type is very small, the xylem is mesarch. Exarch xylem is also found to occur but only in a very few instances.

Where the mesarch condition prevails (Plate 1; Plate 5, figs. 10, 11), the earliest-formed elements of the protoxylem strands are small annular cells. These cells are grouped into well-defined strands situated on the morphologically internal (xylem) side of the primary xylem. On the external (phloem) side of the annular elements may be found "transitional," or helical elements, or both, and one to two metaxylem elements in this order. A similar sequence may be found on the internal (xylem) side of the annular elements. In certain instances, though, no metaxylem elements occur external to the helical elements on the phloem side; in these instances, it is probable that the metaxylem elements are not continuously differentiated over the protoxylem strand.

Where the exarch condition occurs, the outermost elements in the protoxylem region are annular in character and the successively formed ones are cells with "transitional" and helical secondary thickenings. The "transitional" elements are at times omitted in the ontogenetic series.

S. apoda.—The stele is more or less oval or elliptical in shape with two marginal protoxylem poles. (Plate 4, figs. 2, 3, 4)

The protoxylem area is commonly represented by annular and "transitional" elements. The helical elements may also be found, but they are usually wanting.

The number of helices in each helical element is commonly one, rarely two.

The differentiation of the primary xylem is predominantly exarch. Very weakly mesarch xylem was, however, evident in some of the sections examined.

Variations in the ontogenetic succession of the successively differentiated cells following the formation of the first annular cell or cells are observed. The variants may be divided, for convenience, into groups and designated as Groups I, II, III, and IV, as follows:

Group I.—Ontogenetically the earliest annular elements formed are followed immediately by metaxylem elements. Both the "transitional" and helical elements are omitted in the ontogenetic series.

Group II.—The "transitional" elements are differentiated following the formation of the annular cells. Helical elements are wanting.

Group III.—In this type, the helical elements follow the annular cells in the ontogenetic series. The "transitional" elements are absent.

Group IV.—All the cell categories, beginning ontogenetically with the annular cells, followed by the "transitional" elements and culminating with the formation of helical elements, are present in this order.

In the weakly mesarch condition, a similar sequence of transition of cell types in the same ontogenetic series may also be observed but there are, in any case, no metaxylem elements differentiated toward the phloem side of the first-formed annular element or elements.

S. uncinata.—The protostele is ribbonlike in shape. It has a separate strand of xylem situated on the dorsal side of the vascular bundle (Plate 3, fig. 1). This dorsally situated median strand, however, does not form a separate stele but remains distinct. It is separated from the main band of xylem as a distinct cylinder enclosed by parenchyma and phloem cells but still enveloped within the main flattened xylem mass by a common pericycle. The main flattened mass possesses two marginal protoxylem groups along the vertical line where leaf-traces are inserted, one at each point of insertion, sometimes two. The distinct median cylinder has its own protoxylem pole.

According to their wall morphology or sculpturing, two major types of protoxylem cells were observed. These are the annular and the helical elements (Plate 5, figs. 5, 6, 7, 8, 9). "Transitional" elements also exist between the two major elements.

The helical elements contain only one helix or spiral thickening.

Xylem differentiation in this species is essentially exarch. In some sections, though, a situation very suggestive of mesarch development occurs. Plate 3, fig. 1, depicts this situation. This figure shows a group of small, darkly staining protoxylem cells, obviously the earliest-formed elements, grouped into well-defined strands situated on the morphologically internal side of two or several primary xylem elements, which differ markedly in size from the first-formed cells, and which show no signs of degeneration whatsoever. These cells close up in front of the earliest protoxylem strands, so that the first-

formed cells appear to be immersed in a metaxylem. Critical examination of a practicable number of longitudinal sections indicates that the primary xylem cells external to the first-formed ones consist of annular and helical elements with more or less slightly stretched secondary wall thickenings.

OREGANA TYPE

S. rupestris.—The protostele is more or less ribbonlike in shape (Plate 3, fig. 2; Plate 4, fig. 1). Its marginal portions are occupied by four separate protoxylem strands, two to each margin.

The protoxylem contains annular, "transitional," and helical elements in varying amounts. Where the protoxylem strand is relatively large, a greater proportion of the component cells are represented by the helical elements. Very few annular and "transitional" elements are present.

The helical elements contain one or two helices.

Differentiation of the primary xylem is essentially exarch, however, mesarch xylem is also evident. No metaxylem elements are formed on the phloem side of the first annular cell or cells formed in the mesarch xylem. However, "transitional" or helical elements or both are formed external to the first-formed annular element. This observation may be taken as confirmatory evidence indicative of mesarch xylem differentiation in the xylem of this species.

ANOMALOUS MONOSTELIC TYPE

S. braunii.—The stele is ribbonlike in shape (Plate 2). The vascular strand in the basal portions of the stem is slightly grooved or forked at the margins, with a dorsal ridge of xylem prominently projecting midway between the marginal ends. The vascular strand commonly contains from four to five protoxylem strands, two to each marginal end, occasionally three. The more or less medianly situated dorsal ridge has its own protoxylem strand. Though only one such ridge is found in the basal portion, two are observed in sections taken at the terminal portions, but these are only superficially protruded. These dorsal ridges have their own protoxylem strands.

The protoxylem strands contain annular, "transitional," and helical elements (Plate 5, figs. 15, 16). These elements vary in relative proportion depending upon the size of the protoxylem strands. In comparatively large protoxylem strands,

the greater bulk of the component cells are represented by the helical elements. Very few annular and "transitional" elements are present. In certain instances, the "transitional" cells are entirely absent.

The helical elements commonly contain one helix.

Xylem development in this species is mesarch at some loci and exarch at others, either of which may occur marginally or dorsally.

In the mesarch condition, the first protoxylem elements formed are flanked on the phloem side by one or two layers of undestroyed primary xylem cells, as seen in transverse sections. Examination of longitudinal sections shows that these xylem cells are either "transitional" or helical elements or both, in that order. In some cases, metaxylem elements are formed external to the protoxylem region. These observations, therefore, present clear evidence that the differentiation of the primary xylem is mesarch. Very often, metaxylem elements, "transitional," and helical elements are differentiated discontinuously over the protoxylem strands on the phloem side. The xylem, in this case, is exarch in places, mesarch elsewhere.

S. selaginoides.—Transverse and longitudinal sections of the creeping axis were made from materials obtained midway between the points of origin of any two erect shoots. The protostele is more or less circular in outline with a centrally located protoxylem region completely surrounded by metaxylem elements. (Plate 4, fig. 7)

The protoxylem strands are commonly composed of two cell types, namely, the annular elements and the helical elements. The "transitional" elements, found very commonly in other species, are seldom present.

The number of helices in the helical elements is commonly two or three, but rarely one.

The primary xylem of the creeping axis is mesarch in development. (Plate 4, fig. 7)

Similar sections were also made from materials secured from the basal portion of lateral branches at the point where they originate from the creeping axis. The protostele is cylindrical in shape. It possesses variable number of protoxylem groups ranging from two to at most six. These protoxylem groups

are distributed around the stele more or less peripherally but are flanked by metaxylem elements on the phloem side with certain exceptions. The primary xylem is also mesarch in development. (Plate 4, fig. 8)

Sections of the erect axis were secured from pieces of materials taken approximately two centimeters below the shoot apex. The stele is also more or less circular in outline (Plate 4, fig. 9). The vascular bundles contain six protoxylem poles, rarely seven, which are distributed more or less peripherally around the entire girth of the stele.

The primary xylem is essentially exarch in development, although mesarch xylem is also evident in some protoxylem areas.

No substantial differences were found between these portions as regard the various anatomical characteristics of the protoxylem elements.

Ontogenetically, the earliest-formed annular elements are followed by centrifugally and centripetally differentiated helical elements.

GALEOTTEI TYPE

S. kraussiana.—The main axis possesses two distinct protosteles (Plate 4, figs. 5, 6), each lying in wide lacuna. Each protostele possesses one protoxylem strand on the outer margin . . . "at the region between the points of origin of branches" [Harvey-Gibson (33)].

The protoxylem strands contain few tracheary elements. Many of the protoxylem strands contain only one or two annular and usually one "transitional" elements. Very few strands contain helical elements in addition to the other elements.

The first-formed helical elements commonly contain one helix; those formed later may contain one or two.

Xylem differentiation is decidedly exarch, however, a situation very suggestive of mesarch xylem differentiation is also evident. The mesarch condition, nevertheless, was only observed in a few instances. It may therefore be taken as a general statement that the xylem of *S. kraussiana* is primarily and essentially exarch.

DISCUSSION

VARIATIONS IN THE CRITERIA UTILIZED IN THE ANALYSIS OF THE PROTOXYLEM ELEMENTS

The protoxylem strands of the available species of *Selaginella* investigated exhibit certain notable and interesting variations

in the number of protoxylem points occurring in the primary xylem as a whole, in the development of the primary xylem as visualized in time, in the order of transition of the protoxylem cells in the mesarch as well as in the exarch xylem, and in the number of helices in the helical elements.

The variations in the number of protoxylem points in the primary xylem have been indicated in detail for each species. It must be borne in mind, however, that the occurrence of such points is determined and affected roughly by the number of leaf-traces inserted on the vascular cylinder in the main axis and the degree of fusion occurring between these traces themselves.

The number of helices present in the helical elements vary from invariably one or two (*S. martensii, S. apoda, S. uncinata, S. braunii, S. rupestris, S. kraussiana*) to as many as three (*S. selaginoides*). When two are present, the helices are regularly oriented spirally, however, they are not parallel to each other, but make contact with the primary wall on opposite sides of the cell at a given level (Plate 5, fig. 12, upper portion of illustration). In helical elements with only one helical thickening, the helix assumes a clockwise, or counterclockwise pattern of deposition, or a combination of both patterns.

The number of protoxylem cells contained in the protoxylem strands differ in the different species, but no attempt was made to ascertain quantitatively the actual number occurring in such strands. The protoxylem areas as far as can be determined by microscopic examinations, constitute a patch of small disintegrated or obliterated cells, with practically closed or imperceptible lumina. Additional complications are introduced by the formation of protoxylem lacunæ in some of the protoxylem strands, at least in some species, and by the fact that the cells are darkly staining.

Although the variations as regard the sequence of transition of cells in the ontogenetic series are striking, it is rather difficult to draw a sharp demarcation between such variations in the individual species by virtue of the fact that several such variations also occur even within the same species. In order to portray effectively a clear picture of the variations that exist between the individual species and within the same species, a more or less thorough analysis was devoted for each species in the previous section of this paper.

In spite of the obvious variations that occur both between the individual species and within the same species as regard the criteria already pointed out, little or no substantial variations were observed, as far as the anatomical features of the component elements of the protoxylem strands are concerned, in the two sets of samples secured from the main axes of the creeping and the essentially erect species.

Protoxylem lacunæ are formed in some of the protoxylem areas in *S. martensii* and *S. braunii*. The formation of such lacunæ, however, can only be speculated presently. Evidence is available from studies on the protoxylem strands of higher vascular plants which supports the view that the appearance of the protoxylem elements is influenced or modified by the elongation of the organ. Esau(23) observed that the tracheary protoxylem elements of *Zea mays* Linn. mature before the stem or the leaf elongates and are disintegrated in the mature bundles. In their places appear large intercellular spaces. Eames and MacDaniels(22) write that exaggerated protoxylem lacunæ are formed in the protoxylem regions in many herbaceous plants and especially in the monocotyledons and in *Equisetum*, leaving large spaces. The present writer is inclined to believe from the observations of other workers and from his own observations that the manner in which the protoxylem lacunæ are formed in *Selaginella* closely parallels those which have been described in monocotyledons and *Equisetum*.

It may be recalled at this juncture that "protoxylem" as defined by Esau(23, 25) is a tissue which appears at the beginning of vascular differentiation and occupies a characteristic position in the primary vascular system of a given plant organ. Ordinarily a plant organ passes through a period of elongation soon after its inception. The earliest protoxylem cells formed usually mature before the organ completes its elongation. In the process of this elongation the component elements of the protoxylem strands are unable to keep pace with the extension of the adjacent cells and are therefore stretched and most frequently destroyed. During this stretching the primary walls are presumably torn, whereas the secondary walls become distorted. The rings become distantly separated from one another and tilted away from their original positions in various degrees. The helices become greatly extended. When these cells are completely disintegrated protoxylem lacunæ appear in their places.

COMPARISON BETWEEN THE PROTOXYLEM STRANDS OF SELAGINELLA AND OTHER VASCULAR PLANTS

The anatomical characteristics of the protoxylem elements of the geologically ancient vascular plants are imperfectly preserved. This is perhaps one of the drawbacks in attempting to study the component cells of the vascular tissues of these plants. Nevertheless, in the more or less fairly well-preserved materials, histological observations have been made in a few genera. These observations are here utilized in an attempt to compare the protoxylem elements of these plants with those of *Selaginella.*

Histologically, the tracheary elements in the protoxylem strands of *Selaginella* are annular, "transitional," and helical in character. In *Rhynia* [Kidston and Lang(39)], *Zosterophyllum* [Lang(40)], *Psilophyton* and *Baragwanathia* [Smith(50)], only annular elements have been found in the central cylinder. Except for the occasional occurrence of annular cells, the entire xylem mass of the stelar cylinder of *Astoroxylon* is composed of helical elements [Smith(50)].

The protoxylem of *Isoetes* consists of parenchyma cells intermingled with very short helical elements [Smith(50)]. In *Equisetum* [Eames(20)] and *Calamites* [Smith(50)], both annular and helical elements have been reported in the protoxylem strands.

In general, the protoxylem strands of the ferns have been found to contain annular and helical elements [Gwynne-Vaughan(31)]. Bailey(3), (4) and Bailey and Swamy(5) mention that possibly the fern group, Ophioglossales, has a peculiar protoxylem unlike that of the other vascular plants. In this group and in the higher gymnosperms, the Ginkgoales, the Coniferales, and the Gnetales, the helical thickenings are combined with circular bordered pits of the type characteristic of their secondary tracheary elements.

The protoxylem strands of the angiosperms contain annular, "transitional," and helical elements. In contrast to those of *Selaginella,* the protoxylem of the angiosperms contains a considerable proportion of parenchyma cells. The parenchyma cells remain thin-walled after the obliteration of the tracheary elements or become lignified, with or without the development of secondary walls [Raimann(45)].

Moog(43) and Majumdar(42) state that the rings and helices in the protoxylem of angiosperms appear to be firmly attached

to the primary walls by means of "lenticular" thickenings at points where they come in contact with each other. This is also evident in *Selaginella*. Both the selaginellas and the angiosperms contain one to three helices in their helical elements.

The sequence of transition of the protoxylem elements in *Selaginella*, beginning with the annular elements and culminating with the helical elements, sometimes with the omission of one or another type, have also been reported in other vascular plants from the lower [*Psilotum*, Moore and Andrews (44)] to the higher levels [Eames and MacDaniels,(22) Esau (25)] on the phylogenetic scale.

One feature which has not been observed in the protoxylem elements of other vascular plants is the direction of deposition of the helical thickenings in the helical elements. In this genus, it is not uncommon to find the helices to be deposited in clockwise, or counterclockwise pattern, or combination of both in the same helical elements.

An interesting point which has not been studied in the protoxylem strands of this genus is the ontogeny of its individual protoxylem elements. As far as the writer knows, studies along this line have been carried out wholly in the protoxylem strands of a few angiosperms.

Cruger(15) and Sinnott and Bloch(49) found, in their studies of living tracheary elements, that actively streaming bands of densely grannular parietal cytoplasm correspond in position to the future position of the ringlike sculpturings in the annular elements.

Barkley's(8) observations on the helical elements lend support to findings on the annular elements. He found that in the early stages of development of cells destined to become helical elements bands of peripheral cytoplasm precede the spiral markings and become the "bases" of the lignified helices.

The position of the cytoplasmic bands both in the annular [Foster(28)] and helical elements [Barkley(8)] are determined by the pattern of vacuolation in the cytoplasm immediately preceding and during the formation of the cytoplasmic bands.

Majumdar,(41,42) however, contends that the deposition of secondary bands is preceded by the development of "lenticular" thickenings of the primary wall. On these "bases" or projec-

tions the secondary thickenings are ultimately deposited by corresponding bands of cytoplasm. He adds that the primary "bases" are unlignified and consist of both pectin and cellulose.

In view of these conflicting observations, it seems logical to think that the entire problem of the cytological aspects of secondary wall patterns in the protoxylem elements of vascular plants demands further investigation.

PHYLOGENETIC SIGNIFICANCE OF THE DIFFERENT TYPES OF PRIMARY XYLEM

The primary xylem of the stem of *Selaginella* has long been held to be essentially exarch in development [Bower,(9, 10) Eames,(21) Schoute,(47) Smith,(50) and many others] with the exception, perhaps, of *S. spinosa* which has been reported to possess both the exarch and endarch xylem differentiation [Bower,(9, 10) Schoute,(47)]. Whether the endarch xylem designated in this particular species is authentic or not has not been verified and the writer does not propose to settle it here. The writer, however, now reports the occurrence not only of exarch xylem but also of mesarch xylem in *Selaginella*. Mesarch xylem differentiation has not been reported in this genus previous to this paper.

By virtue of the current findings and those of other workers, the interesting question, "Is exarch xylem more primitive than mesarch xylem or vice versa?," arises. The answer to this question rests upon the analysis of work accomplished so far on the order of differentiation of the xylem in other vascular plants.

A survey of results of the extensive, as well as intensive, comparative anatomical studies compiled by competent authorities along this line is indicated in the following paragraphs.

In Psilophyta, exarch xylem has been reported in *Asteroxylon, Psilotum, Bothrodendron, Sigillaria, Pleuromeia* [Smith (50)]; in *Selaginella, Lepidodendron, Isoetes, Sphenophyllum* [Eames,(21) Smith(50)]; in *Lycopodium* [Jeffrey,(37) Eames, (21) Smith(50)]; and in *Gosslingia* [Schoute(47)].

In Pterophyta, exarch xylem is reported in *Botryopteris, Zygopteris, Anachoropteris,* among the fossil forms; in *Lygodium* (Schizaeaceæ), members of the family Hymenophyllaceæ, among the primitive living forms [Worsdell(60)].

Exarch xylem has also been reported in other members of the fern series, such as *Platyzoma* (Gleicheniaceæ), *Anemia* (Schizacaceæ), members of the family Ophioglossaceæ, Marattiaceæ, Cyatheaceæ, Dicksoniaceæ, and in almost all of the most advanced of the fern series, the Polypodiaceæ [Worsdell, (60)]. Smith(50) reports that *Marsilea vestita* Hook. and Grev. (Marsileaceæ) also exhibits exarch xylem.

In other ferns, such as *Iridopteris* [Arnold(1)], *Osmunda, Matonia, Cyathea,* and representatives of the family Hymenophyllaceæ [Smith(50)], the xylem is mesarch in development.

Pitys, Calamopitys, and *Dadoxylon,* forms perhaps allied to the *Cordaites,* show mesarch xylem differentiation [Scott(48)].

The primary xylem of *Lyginodendron, Poroxylon,* and others [Worsdell,(60) Arnold(2)]; *Tmesipteris* [Eames,(21) Schoute,(47) Smith(50)]; *Horneophyton* [Schoute(47)] is mesarch in development.

In the stems of the higher vascular plants, such as the Cycadales, Gnetales, Ginkgoales, Coniferales, and the Angiospermæ, the endarch condition is a feature of the development of the primary xylem [Worsdell,(60) Jeffrey(37)].

It is clear from the evidence given above that exarch xylem occurs in the fossil forms and in the primitive living forms. Mesarch xylem is evident among the ferns and lower gymnosperms. On arriving at the level of the angiosperms, all trace of any vestige of the mesarch xylem has completely vanished and the purely endarch xylem prevails almost everywhere. These observations led Worsdell(60) and Jeffrey(37) to interpret that the exarch xylem, by reason of its prevalence among the lower groups, is more primitive than the mesarch xylem, and that the latter is more primitive than the endarch xylem. For a more comprehensive review of the concept the reader is referred to the original paper of Worsdell.(60) More recently, Esau(25) states that the exarch and mesarch xylem appear to be more primitive than the endarch xylem.

In spite of the general occurrence of the exarch xylem in the stems of ancient and primitive vascular plants, some investigations indicate that the mesarch and endarch xylem also occur in some of the earliest vascular plants. Schoute(47) reports that endarch xylem occurs in the primary vascular tissues of *Rhynia major* Kidston and Lang. If, however, one restricts

the use of the term "endarch" to the circumstance where primary xylem differentiation is bidirectional, then the xylem *of Rhynia* would necessarily be described as mesarch. The primary xylem of *Phylloglossum* is mesarch [Eames(21)]. Eames(20) and Smith(50) indicate the presence of endarch xylem in *Equisetum* and *Ophioglossum*, respectively. Eames (21) writes that in *Asteroxylon* and *Psilotum*, both exarch and mesarch xylem occur in the stem. The occurrence of exarch as well as mesarch xylem differentiation in *Selaginella* is presently reported.

Accounts pertaining to the xylem differentiation in the stem of *Gleichenia*, considered to be a primitive fern, are conflicting. Worsdell(60) states that the xylem of this genus is exarch. Smith,(50) on the other hand, records that it is mesarch.

In the light of the above evidence, attempts to attach phylogenetic significance to the succession of developmental patterns of the primary xylem seem to lose much of their validity. In short the proposition that the exarch xylem is the most primitive is probably inconclusive. These facts, however, do not entirely negate the interpretation advanced earlier by Worsdell and Jeffrey, but it is not unreasonable nor improbable to propose that endarch xylem, or mesarch xylem, are also primitive, in view of their reported occurrence in the earliest known vascular plants. Schoute(47) states that perhaps the more simple suggestion may be advanced that when for some unknown reason the protoxylem changes its position, the metaxylem having to put up with the space left, is obliged to develop in another direction.

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ILLUSTRATIONS

PLATE 1

Diagram of transverse section of the protostele of *S. martensii* taken below the shoot apex showing mesarch xylem and six distinct protoxylem loci.

PLATE 2

Diagram of transverse section of the protostele of *S. braunii* taken from the basal portion of the main axis showing mesarch and exarch xylem and six distinct protoxylem loci.

PLATE 3

FIG. 1. Diagram of transverse section of the protostele of *S. uncinata* taken from the basal portion of the main axis showing exarch xylem and three protoxylem loci.

2. Diagram of transverse section of the protostele of *S. rupestris* taken from the basal portion of the main axis showing exarch xylem and two marginal protoxylem strands.

PLATE 4

FIG. 1. Diagram of transverse section of the protostele of *S. rupestris* taken below the shoot apex showing mesarch and exarch xylem and two marginal protoxylem loci.

2. Diagram of transverse section of the protostele of *S. apoda* taken from the basal portion of the main axis showing exarch xylem and two marginal protoxylem loci.

3–4. Diagrams of transverse sections of the protosteles of *S. apoda* taken below the shoot apex showing mesarch and exarch xylem and two protoxylem loci situated marginally in each case.

5–6. Diagrams of transverse sections of the steles of *S. kraussiana* taken from the basal portion of the main axis showing exarch xylem and the marginal protoxylem loci.

7. Diagram of transverse section of the protostele of *S. selaginoides* taken from the basal portion of the main axis showing mesarch xylem and the centrally located protoxylem locus.

8. Diagram of transverse section of the protostele of *S. selaginoides* taken from the basal portion of a branch near its point of origin from the main axis showing mesarch xylem and four peripheral protoxylem loci.

9. Diagram of transverse section of the protostele of *S. selaginoides* taken below the shoot apex showing exarch and mesarch xylem and six peripheral protoxylem loci.

PLATE 5

FIG. 1–4. Protoxylem elements of *S. martensii*. 1, "transitional" element; 2, 3, and 4, helical elements.

5–9. Protoxylem elements of *S. uncinata*. 5, 6, annular elements; 7, helical element; 8, 9, "transitional" elements.

10. Protoxylem elements of *S. martensii* showing the order of transition of protoxylem cells in a mesarch xylem. *a*, parenchyma cells; *b*, metaxylem element; *c*, "transitional" element; *d*, annular element; *e*, helical element; and *f*, metaxylem element.

11. Protoxylem elements of *S. martensii* showing the sequence of transition of cells in a mesarch xylem. *a*, parenchyma cells; *b*, *c*, helical elements; *d*, annular cell; *e*, helical element.

12–14. Protoxylem elements of *S. selaginoides* showing the characteristic occurrence of two helical bands in helical cells and the direction of deposition of each.

15. Protoxylem elements of *S. braunii* showing the order of transition of cells in a mesarch xylem. *a*, parenchyma cells; *b*, helical cell; *c*, longitudinally stretched helical cell; *d*, annular cell; *e*, helical cell; *f*, metaxylem element.

16. Protoxylem elements of *S. braunii* showing the order of transition of cells in a mesarch xylem. *a*, parenchyma cells; *b*, helical cell; *c*, "transitional" cell; *d*, annular cell; and *f*, helical cell.

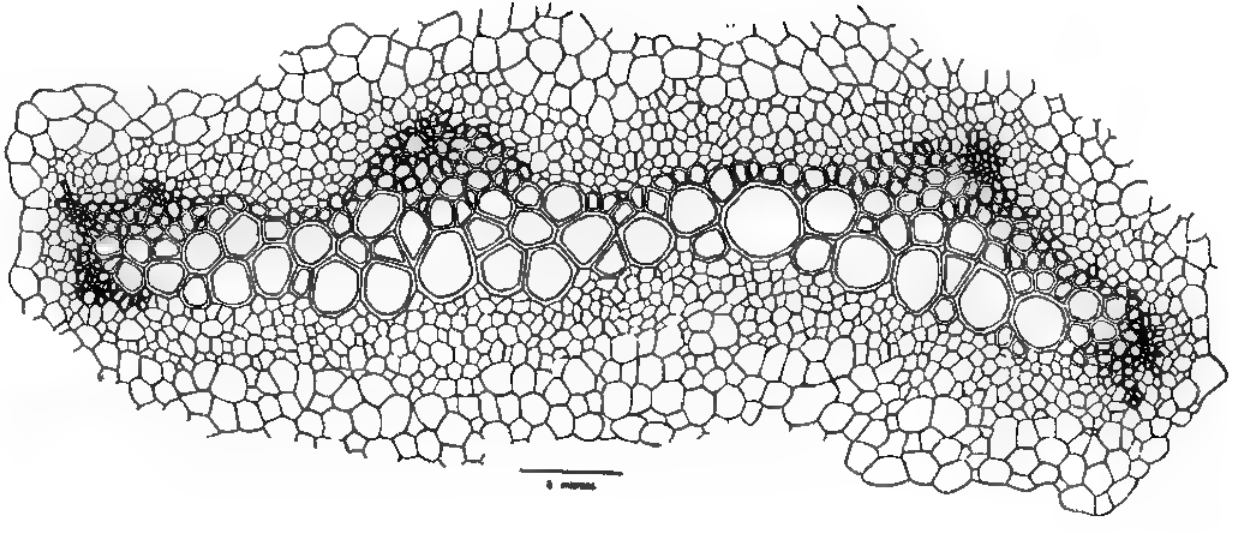
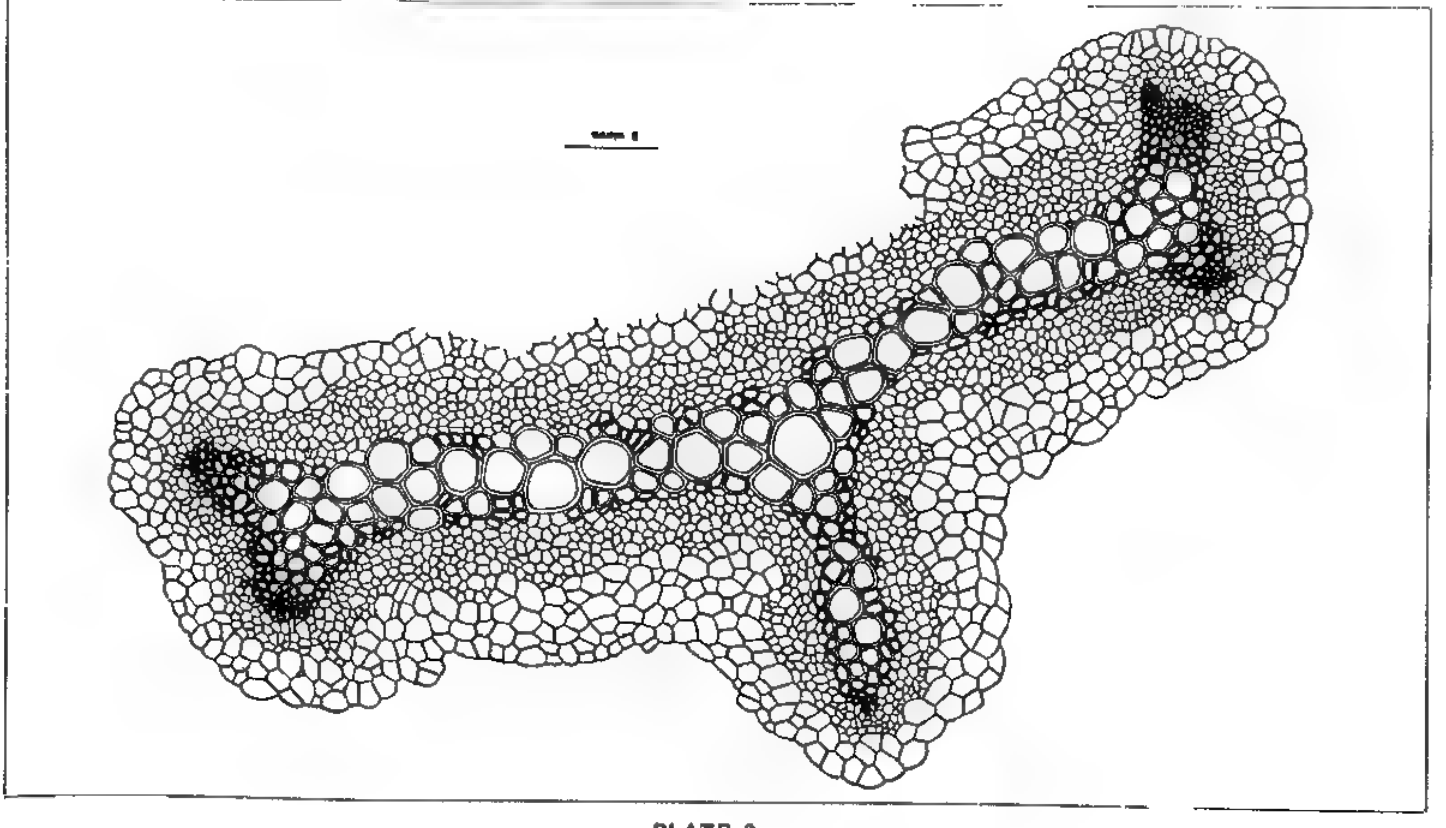


PLATE 1.



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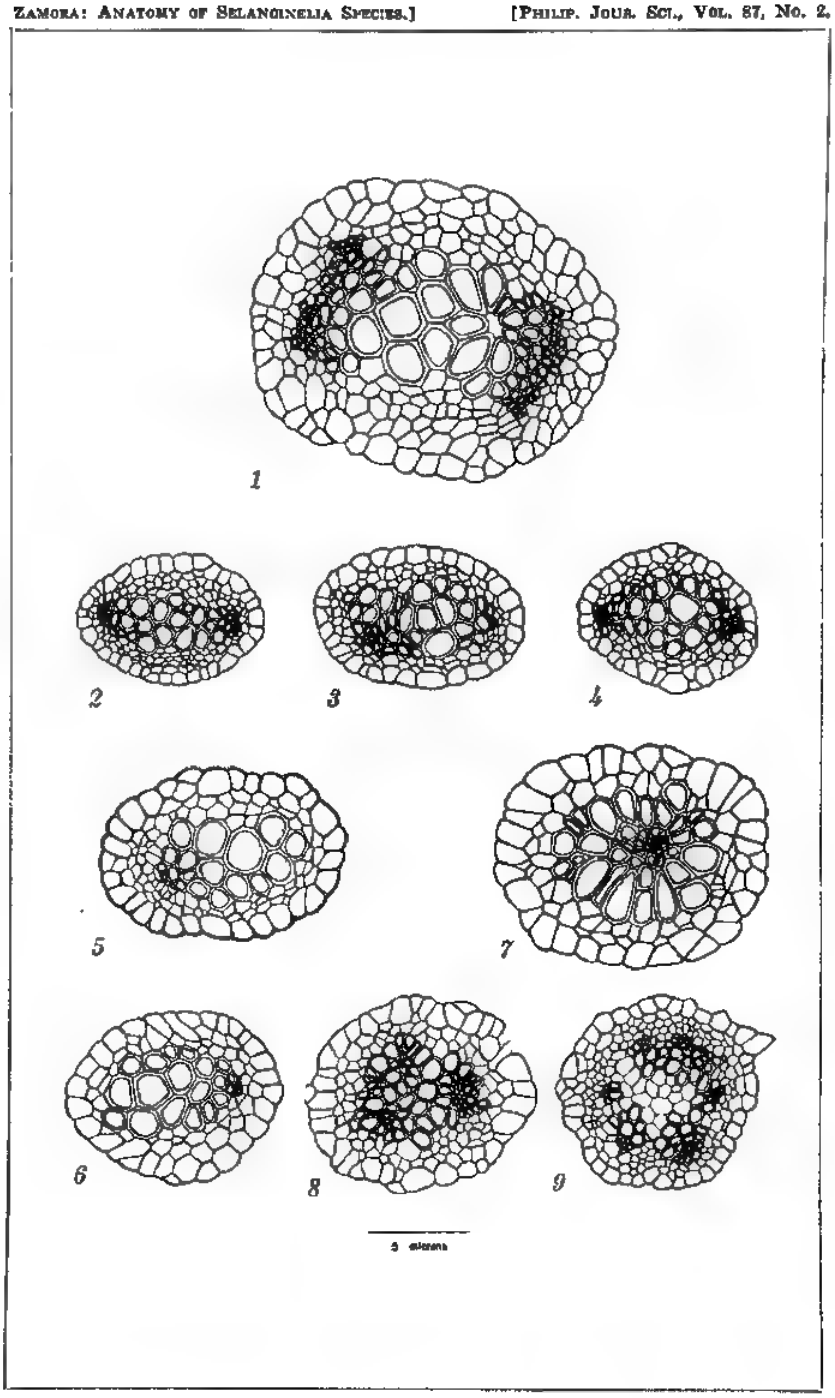

PLATE 4.

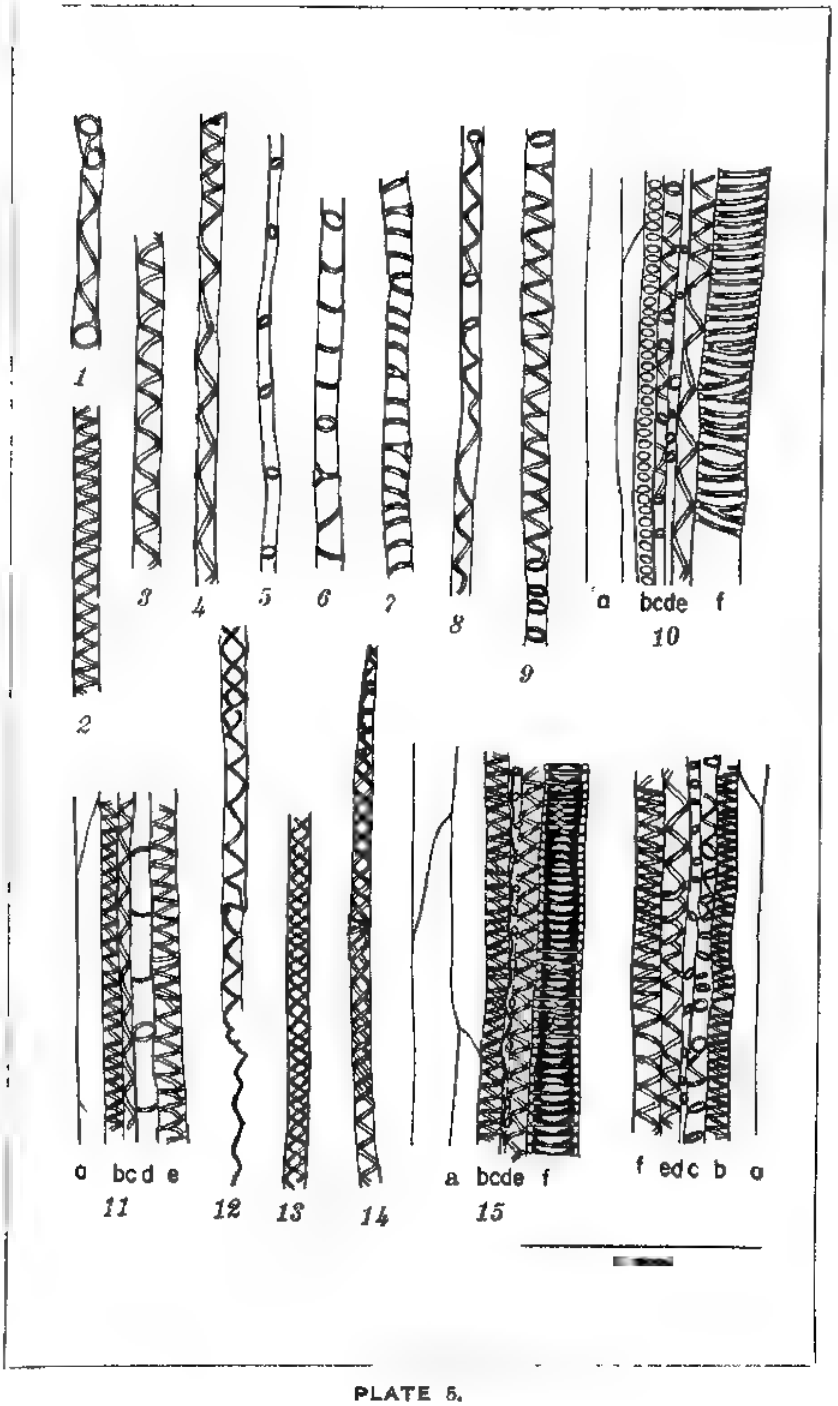

PLATE 5.

AN UNREPORTED PRIMITIVE VASCULAR PLANT IN THE PHILIPPINES

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ONE PLATE

There are reports that *Psilotum* and its close relative, *Tmesipteris*, occur in the tropical and subtropical regions in both the Eastern and Western Hemispheres [Eames,(2) Haupt,(3) Smith (4)]. *Tmesipteris*, however, is restricted only to such places as Australia, New Zealand, Polynesia, and the Philippines. Little is known about these plants generally because of their restricted distribution. Their probably closest relatives are known only in fossil records in the Devonian flora of Rhynie, Scotland; Bohemia; eastern part of the United States; Australia; and Elberfeld, Germany [Arnold,(1) Smith(4)]. *Psilotum* and *Tmesipteris* are the only living representatives of these most primitive vascular cryptogams.

The psilophyte under report is probably *Psilotum triquetrum* Swartz.[1] The plant was found by the writers growing pendantly at the groove of a forked trunk of a cainito tree (*Chrysophyllum cainito* Linn.) in front of the entomology building, College of Agriculture, University of the Philippines, College, Laguna. There are no previous records of *Psilotum* in the Philippines.

The sporophyte is an epiphyte. It consists of a rhizomaceous axis bearing rhizoids, and slender, green, pendant aerial axis. The aerial axis branches dichotomously in succession at right angles. The basal portion of the shoot is quadrangular and radially symmetrical; the distal portion is triangular; both bear longitudinal ribs. The sterile appendages borne on the dichotomies are minute, scalelike, and more or less regular in distribution. The plant was without sporangia when found by the writers.

[1] Identity verified by Dr. E. M. Palmquist, Cornell visiting professor of botany detailed in the College of Agriculture, University of the Philippines.

The plant has the following botanical circumscription:

Division: Psilophyta
Subdivision: Psilophytina
Class: Psilopsida
Order: Psilotales
Family: Psilotaceæ

Psilotum is important phylogenetically because it demonstrates some of the basic characters possessed by the oldest vascular stock, the most outstanding of which is probably the lack of organ differentiation of its parts.

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ILLUSTRATION

PLATE 1

A primitive vascular plant found by the writers growing pendantly at the groove of a forked trunk of a cainito tree in front of the entomology building, College of Agriculture, University of the Philippines. The psilophyte is probably *Psilotum triquetrum* Swartz.

PLATE 1.

PROXIMATE CHEMICAL ANALYSES OF SOME PHILIPPINE BARKS, WOODS, AND BAMBOOS *

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ONE PLATE AND THREE TEXT FIGURES

According to Tamesis and Aguilar(11) over 3,000 arborescent species are found in Philippine forests. Some 65 of these are handled by sawmill operators to produce lumber, both for local consumption and for export. Not much use so far has been found for the rest except perhaps as firewood or fence posts. Research, however, may yet find more uses for these species.

About 30 species of bamboos are found in the Philippines. According to Brown(3) all species are useful for varied domestic purposes. They offer, also according to him, many promising possibilities for export as paper pulp, hats, baskets, mats, and matting.

The Forest Products Research Institute, College, Laguna, has, among its important projects, the finding of ways and means by which weed tree species that abound in the Philippines as well as wood-residues from the logging areas, sawmill, and veneer plants could be profitably utilized. For instance, it is looking into the possibility of converting these materials into pulp and paper, lump and briquetted charcoal, or of using them as sources of tanning, dyes, or resin.

To ascertain those suitable for pulpmaking, tannin extraction, or other purposes, the exploratory proximate chemical analyses of the different species of wood were undertaken. Information on their chemical composition may be, in many cases, of importance in considering the end uses to which these species may be put to best advantage and in exploring the special properties of certain species. For example, if analysis shows that a certain wood species is high in silica, it is possible that that species will be resistant to the attack of marine borers and probable that it will have a tendency to dull cutting tools. A species high in leachable extractives may be a good source of tannin, resin, or dye. Those high in cellulose content can be expected to yield more chemical pulp per ton of wood than species that are low in this; species high in pentosans may yield a semi-

* An abstract of this paper was read before the Ninth Pacific Science Congress held in Bangkok, November 18 to December 9, 1957.

chemical pulp of high strength.(10) Numerous chemical analyses were undertaken in the past to ascertain whether the chemical composition of wood could be a guide to the treatment to be used during pulping. In this regard, R. Peteri(7) disclosed that the chemical composition of wood does not seem to have any influence or, perhaps, only a very slight influence on the cooking conditions.

Anderson(1) writes, "Tree species vary in properties because of the chemical nature of their respective extractive components . . . Trees are composed of a myriad of complex organic compounds, most abundant of which are cellulose, lignin, hemicellulose, and extractives." Extractives are those substances in trees and in the exudates therefrom which are soluble in organic solvents or water. They are not integral parts of the cellular structure.

It is disclosed(6) that some extraneous components of the pulpwoods of America are extremely important from the standpoint of the paper industry and related areas, and at times these are out of proportion to the quantities actually present in the wood or pulp. It was stated further that the color of wood, its odor, and its taste are due to extraneous components. "In other words, these extraneous components 'fingerprint' a wood and give it a certain chemical specificity."

Not much research work has been done on the production of dissolving pulps from tropical hardwoods. Great difficulties are encountered owing chiefly to their high pentosan and ash contents (especially silica).(7) Similarly, a complete chemical analysis of a wood sample, including the chemical identification of all the compounds it contains, is not practical. A lifetime could be spent on one species without certainty that every chemical compound it contained was separated quantitatively and identified exactly. For practical purposes, only a few groups of components are determined in a general exploratory survey. Greater detail may be sought later on any species that seems interesting for some special purposes.

More than 25 years ago, Yenko, et al.,(18) conducted studies on the chemical compositions of about 73 species of Philippine woods. Their analyses covered wood solubilities in cold and hot water, alkali, ether, and alcohol. They also determined the percentages of ash, nitrogen, lignin, and cellulose in wood; ash in cellulose, ash-free cellulose, alpha cellulose in total cellulose, and alpha cellulose in the wood.

MATERIALS USED

The exploratory survey reported herein covered 60 barks, 95 wood species (93 hardwoods and 2 softwoods), and 5 bamboos gathered from the forests of Laguna, Quezon, and Mindanao, Philippines. The logs were brought to this Laboratory specifically as samples for strength tests, fiber measurement, density determination, proximate chemical analysis, pulping studies, and for other purposes. Each tree or bamboo was selected in the forest so as to be as nearly as possible truly representative of the species and botanical samples were preserved from each to assure correctness of identification.

The details of selection, collection, sampling and recording were in accordance with the "Instructions for the selection and collection of authentic timber samples for forest products research." (8)

The official local names (in alphabetical order) of these species, together with their scientific names, are listed in Tables 1, 2, and 3.

TABLE 1.—*Proximate chemical analyses of barks of some Philippine woods.*

(Percentages on oven-dry basis)

Local and scientific names	Ash	Alcohol-benzene extract	Hot-water extract w/o prior leaching
1. Acacia (*Samanea saman*)	6.9	10.6	15.0
2. African tulip (*Spathodea campanulata*)[1]	7.6	9.2	24.9
3. Alu (*Anisoptera brunnea*)[2]	9 6	7.7	11.0
4. Agoho (*Casuarina rumphiana*)	6 6	7 7	18.0
5. Alagasi (*Leucosyke capitellata*)	17 2	5 4	33.0
6. Amugis (*Koordersiodendron pinnatum*)	9.3	6.8	23.8
7. Anabiong (*Trema orientalis*)	13.7	3.7	21.7
8. Anang (*Diospyros pyrrhocarpa*)	4.0	11.6	14.5
9. Anang-gulod (*Diospyros inclusa*)	4 5	3 8	11.3
10. Anilau (*Columbia serratifolia*)	11.4	1 9	13.7
11. Apitong (*Dipterocarpus grandiflorus*)	31 7	3.7	7.7
12. Ata-ata (*Diospyros mindanaensis*)	6.4	3.6	10.5
13. Bagtikan (*Parashorea plicata*)	2.8	2.6	7.2
14. Bagtikan (southern) branch (*Parashorea warburgii*)	4.0	6.2	9.3
15. Balikbikan (*Drypetes bordenii*)	7 9	6 1	13.9
16. Balobo (*Diplodiscus paniculatus*)	16 2	6 6	11.7
17. Batag-ukal (*Griffithianthus merrillii*)	4.9	7 5	8.1
18. Batino (*Alstonia macrophylla*)	3.5	11.1	10.4
19. Bunggas (*Terminalia comintana*)	20.3	10.7	24.7
20. Binunga (*Macaranga tanarius*)	9.5	4.7	18.7
21. Bokbok (*Xanthoxylum excelsum*)	8 4	2 9	6.4
22. Bunya pine (*Araucaria bidwillii*)	3 7	9 0	28.7
23. Casia (*Casia spectabilis*)	6.9	10.7	19.9
24. Cinchona (*Cinchona succirubra*)	2.5	29.0	29.2
25. Dagang (*Anisoptera aurea*)	4.0	7.5	9.9
26. Daha (*Macaranga candatifolia*)	10.7	1 8	9.4
27. Dalingdingan (*Hopea foxworthyi*)	8 5	18 3	18.5
28. Dinsi (*Terminalia pellucida*)	17 6	7 4	29.0
29. Dolalog (*Vitex integrifolia*)	15.5	10.8	20.0
30. Duliran (*Palaquium merrillii*)	6.9	10 6	21.2
31. Gubas (*Endospermum peltatum*)[1]	4.4	3.6	7.6

[1] Average of 2 samples.
[2] Average of 3 samples.

TABLE 1.—*Proximate chemical analyses of barks of some Philippine woods*—Continued.

Local and scientific names	Ash	Alcohol benzene extract	Hot-water extract w/o prior leaching
32. Guijo (*Shorea guiso*)	12.7	6.6	17.2
33. Guijo branch (*Shorea guiso*)	11.7	5.8	16.7
34. Hagakhak (*Dipterocarpus warburgii*)	30.9	2.6	9.3
35. Hagumit (*Ficus minahassae*)	10.1	4.8	13.1
36. Hamindang (*Macaranga bicolor*)	17.6	2.1	16.3
37. Hasselt's-panau (*Dipterocarpus hasseltii*)	24.1	4.5	10.8
38. Himbaba-o (*Allacanthus luzonicus*)	11.9	10.3	12.2
39. Himlaumo (*Mallotus ricinoides*)	8.4	12.4	23.0
40. Igem (*Podocarpus javanicus*)	5.5	2.9	6.7
41. Ilang-ilang (*Cananga odorata*)[1]	5.6	3.5	10.6
42. Ipil (*Intsia bijuga*)	5.7	8.1	11.8
43. Ipil-ipil (*Leucaena glauca*)	11.1	10.2	26.4
44. Kantoan bangkal (*Nauclea horsfieldii*)[2]	5.5	11.8	20.9
45. Kamagong (*Diospyros discolor*)	8.8	19.7	24.8
46. Kapok (*Ceiba pentandra*)	6.4	3.6	15.0
47. Katilma (*Diospyros nitida*)[1]	7.0	4.0	8.2
48. Katmon (*Dillenia philippinensis*)	9.1	9.2	15.7
49. Katurai (*Sesbania grandiflora*)	8.8	4.5	16.2
50. Kupang (*Parkia javanica*)	10.2	8.4	24.6
51. Labayo (*Melochia umbellata*)	5.6	4.5	14.0
52. Lasak (*Neonauclea barlingii*)	3.6	12.6	22.2
53. Loktob (*Duabanga moluccana*)	7.4	5.6	25.0
54. Lumbang (*Aleurites moluccana*)	7.4	2.6	8.7
55. Mahogany (*Swietenia macrophylla*)	6.6	16.1	27.4
56. Malakalumpang (*Sterculia ceramica*)	8.9	1.7	9.8
57. Magtungan (*Syzygium alcinae*)	2.3	6.4	18.7
58. Malapanau (*Dipterocarpus Kerrii*)	15.7	3.7	9.7
59. Malapapaya (*Polyscias nodosa*)	11.6	9.6	14.7
60. Malibayo (*Berria cordifolia*)	3.1	8.3	16.9
Average	9.3	7.5	16.3

[1] Average of 2 samples.
[2] Average of 3 samples.

TABLE 2.—*Proximate chemical analyses of some species of Philippine woods.*
(Percentages on oven-dry basis)

Local and scientific names	Ash	Alcohol-benzene extract	Solubility in hot-water after alcohol-benzene extraction	Solubility in hot-water w/o prior leaching	Lignin	Holocellulose	Pentosans	Silica	Solubility in 1 Per cent NaOH
1. Acacia (*Samanea saman*)	2.4	8.7	5.2	10.2	25.3	58.4	18.4	1.4	31.9
2. African tulip (*Spathodea campanula(a)*)[1]	1.8	3.7	4.5	8.3	27.1	63.1	16.1	0.07	17.7
3. Afu (*Aniosptera brunnea*)	1.0	5.3	1.4	2.8	26.7	65.6	17.1	------	14.8
4. Agoho (*Casuarina equisetifolia*)	0.8	2.5	2.2	4.1	26.1	68.4	19.4	------	13.0
5. Agoho (mountain) (*Casuarina rumphiana*)	0.5	1.7	1.4	3.5	24.3	71.6	19.5	------	12.1
6. Alagasi (*Leucosyke capitellata*)	3.5	1.5	3.1	4.0	34.4[2]	57.5	15.6	1.8	20.8
7. Amugis (*Koordersiodendron pinnatum*)	1.3	1.9	3.4	5.4	22.1	71.3	19.5	------	20.8

[1] Average of 2 samples.
[2] Lignin including ash.

TABLE 2.—*Proximate chemical analyses of some species of Philippine woods*—Continued.

Local and scientific names	Ash	Alcohol-benzene extract	Solubility in hot-water after alcohol-benzene extraction	Solubility in hot-water w/o prior leaching	Lignin	Holocellulose	Pentosans	Silica	Solubility in 1 Per cent NaOH
8. Anabiong (*Trema orientalis*)	1.6	2.1	3.4	4.5	22.8[3]	70.1	20.9	.....	18.6
9. Anang (*Diospyros pyrrhocarpa*)	2.3	5.0	1.9	5.5	28.3	62.5	17.3	0.3	15.3
10. Anang-guiod (*Diospyros inclusa*)	1.6	2.0	1.5	2.6	28.9	66.0	16.4	.....	10.3
11. Anilan (*Columbia serratifolia*)	1.9	1.4	2.3	4.0	28.2	64.7	18.4	.....	17.9
12. Apitong (*Dipterocarpus grandiflorus*)	1.5	3.2	2.1	5.4	28.9[3]	60.3	16.5	.....	21.2
13. Apitong (round-leaved) (*Dipterocarpus orbicularis*)	1.1	4.6	2.3	4.5	28.6[3]	63.4	14.7	.....	14.4
14. Ata-ata (*Diospyros mindanensis*)	1.8	1.8	1.8	2.9	29.7	65.4	16.6	0.25	10.8
15. Bagtikan (*Parashorea plicata*)[1]	1.3	3.1	1.5	2.9	28.9	65.3	15.2	.....	11.9
16. Bagtikan (southern branch) (*Parashorea warburgii*)	0.7	3.0	1.7	3.7	27.7	66.9	18.5	.....	13.6
17. Bahabikan (*Drypetes bordenii*)	1.0	3.4	3.0	5.6	28.3	63.3	16.9	.....	12.8
18. Balobo (*Diplodiscus paniculatus*)	3.9	6.0	3.5	8.9	27.1	58.9	16.2	.....	21.3
19. Betag-ukai (*Griffithianthus merrillii*)	0.7	6.0	2.4	6.5	26.6	64.3	15.8	.....	16.8
20. Batino (*Alstonia macrophylla*)	0.6	5.1	0.9	4.3	23.7	69.7	20.4	.....	17.6
21. Binggas (*Terminalia comintana*)	2.1	2.8	4.3	5.8	27 6	63 2	14 9	0.8	13.5
22. Binuñga (*Macaranga lanarius*)	1.7	2.5	5.2	9.3	29.8	60.7	15.2	0.09	21.7
23. Bokbok (*Xanthophyllum excelsum*)	1.4	3.9	2.5	5.8	29.6	62.5	15.1	.....	13.6
24. Bunya pine (*Araucaria bidwillii*)[2]	0.5	2.6	1.8	3.3	28.0	67 1	14.4	.....	14.1
25. Casia (*Cassia spectabilis*)	0.2	4.0	1.0	4.3	21.3	73.5	22.5	.....	17.7
26. Cinchona (*Cinchona succirubra*)	0.8	15.9	1.0	11.8	24.8	58.0	17.4	.....	25.6
27. Dagang (*Anisoptera aurea*)	2.3	4.8	2.8	4.3	24.7	65.4	17.3	1.7	16.1
28. Daha (*Macaranga candalifolia*)	1.3	1.3	0.9	1.2	34.0	62.5	14.4	.....	13.5
29. Dalingdingan (*Hopea foxworthyi*)	1.5	7.8	1.2	3.0	24 3	66.2	17.2	.....	14.3
30. Dalinsi (*Terminalia pellucida*)	1.6	4.3	5.6	8.9	26.4	62.2	11.5	.....	20.4
31. Dangkalan (*Calophyllum obliquinervium*)	0.6	3.8	1.0	2.1	29.5	65.1	15.0	.....	16 0
32. Delalog *Ficus integrifolia*)	5.5	3.6	2.4	3.5	25.6	61.9	14.1	0 04	21.5
33. Dulitan (*Palaquium merrillii*)	3.4	3.0	1.2	3.6	24.7	67.7	15.1	.....	14.5
34. Gubas (*Endospermum peltatum*)[1]	1.3	1.9	2.9	4.2	27.7	68.3	16.6	.....	15.4
35. Guijo (*Shorea guiso*)	1.8	5.1	1.8	4.7	29.4	61.9	16.0	.....	15.7
36. Guijo branch	0.8	4.5	2.5	5.2	24.9	67.3	18.6	.....	16.6
37. Hagakhak (*Dipterocarpus warburgii*)	1.2	3.5	1.7	3.0	30 5	62.1	15.5	.....	11.5
38. Hagimit (*Ficus minahassae*)	2.7	2.1	3.5	3.8	26.3	65.4	18.5	.....	17.1
39. Hamindang (*Macaranga bicolor*)	1.2	3.0	4.1	7.2	31.9	59.8	13.8	.....	18.9
40. Hassolt's-panau (*Dipterocarpus hasseltii*)	1.2	4.2	2.7	4.0	28 7	63.2	16.7	.....	16.8
41. Himbaba-o (*Allaeanthus luzonicus*)	2.1	3.2	1.5	3.4	25.6	67.6	20.8	0.21	16.9
42. Hinlaumo (*Mallotus ricinoides*)	0.9	3.4	3.8	7.0	20.3	71.6	21.6	.....	23.7
43. Igem (*Podocarpus javanicus*)[2]	0.3	0.2	0.5	1.1	29 1	69 1	9.8	.....	10.4
44. Ilang-ilang (*Cananga odarata*)[1]	1.3	3.2	4.5	7.2	25.9	65 8	17.7	.....	16.8
45. Ipil (*Intsia bijuga*)	0.9	5.6	3 7	8 2	22.6	67 2	17.1	.....	21.9
46. Ipil ipil (*Leucaena glauca*)	0.7	7.2	2 4	6.2	24.3	65.4	16.7	.....	16.7
47. Kantoan bangkal (*Nauclea horsfieldii*)[1]	0.8	3.8	2.6	5.9	23.8	69.0	21.2	.....	20.2

[1] Average of 2 samples.
[2] This is softwood.
[3] Lignin including ash.

TABLE 2.—*Proximate chemical analyses of some species of Philippine woods*—Continued.

Local and scientific names	Ash	Alcohol-benzene extract	Solubility in hot-water after alcohol-benzene extraction	Solubility in hot-water w/o prior leaching	Lignin	Holocellulose	Pentosans	Silica	Solubility in 1 per cent NaOH
48. Kamagong (*Diospyros discolor*)	2.2	5.7	2.9	7.0	25.7	63.5	15.1	0.02	17.0
49. Kapok (*Ceiba pentandra*)	4.5	12.4	12.0	14.2	21.7	59.4	18.9	0.99	26.9
50. Kati-an (*Diospyros nitida*)[1]	1.7	1.8	1.9	2.8	26.4	67.8	17.1	0.04	11.2
51. Katmon (*Dillenia philippinensis*)	1 6	3.9	6.1	9.3	26 8	61 6	11.4	0 3	22.6
52. Katurai (*Scaphium grandiflora*)	1.7	2.9	2.6	4.5	25.6[2]	60.4	20.0		16.4
53. Kupang (*Parkia javanica*)	2.5	5.0	2.7	5.5	26.0	65.7	18.9	1.4	16.6
54. Lahayo (*Melochia umbellata*)	1.0	1.3	1.0	3.0	22.7	74.0	22.7	------	18.6
55. Lan-pau (*Terminalia crassiramea*)	0 7	1.5	4.0	-- .	30 5	63.3	17.1	------	13.9
56. Lanutan bagyo (*Gonystylus bancanus*)	2.0	3.3	2.6	5.3	27.0	65.1	19.4	0.84	14.9
57. Lisan (*Neonauclea bartlingii*)	0.7	6.6	2.3	8.5	31.4	59 0	15.2	------	15.1
58. Loktob (*Dualanga moluccana*)	1.6	2.5	3.8	5.3	24.3	68.0	16.6	------	15.0
59. Lumbang (*Aleurites moluccana*)	2.2	1.8	6.4	10.7	27.1	62.5	20.5	1.1	23.6
60. Mahogany (*Swietenia macrophylla*)	0.7	9.5	1.8	9.5	24 4[2]	64.1	17.7	--	22.3
61. Magtungau (*Syzygium alcinae*)	0.7	5.5	3.1	4.2	17.5	73.2	15.0	------	20.3
62. Malakaiumpang (*Sterculia ceramica*)	3.4	3.8	7.9	10.1	20.5[2]	64.4	18.6	0.05	23.2
63. Malapanau (*Dipterocarpus kerrii*)	1.1	4.3	3.8	5.5	26 8	64.0	15.2	------	16.6
64. Malaruhat (branch) (*Syzygium simile*)	1.4	7.2	3.5	4.7	25.5	63.4	19.2	------	22.2
65. Malapapaya (*Polyscias nodosa*)	1.5	5.3	3.2	7.5	23.0	67.0	24.7	------	25.0
66. Malibayo (*Berria cordifolia*)	1.0	2.1	3.3	5.2	27.9	65.7	17.2	------	16.9
67. Malubago (*Hibiscus tiliaceus*)	3.5	3.8	2.9	5.6	24.8	65.0	15.3	0.0	16.8
68. Malugai (*Pometia pinnata*)	1.1	2.8	3.7	6.2	24.9	67.5	15.3	------	15.6
69. Manggasmoro (*Shorea philippinensis*)	1.2	3.2	0.8	2.3	26 9	67.9	15.6	1.0	10.2
70. Marang (*Luisea perrottetii*)	1.2	5.2	5.5	7.1	22.0	66.1	21.2	. .	22.3
71. Mayapis (*Shorea squamata*)	0.2	5.6	2.8	6.2	30.7	60.7	12.1	------	18.2
72. Miao (*Dysoxylum cuphebium*)	0.7	5.8	2.6	5.6	30.3	60.6	16.0	------	14.1
73. Mosboron (*Scaevola frutescens*)	2.0	4.5	3.5	6.0	19.4	70.6	16.0	------	24.7
74. Narig (*Vatica mangachapoi*)	1.0	13.5	2.8	8.5	21.2[2]	61.5	16.8	------	24.7
75. Narra (*Pterocarpus indicus*)	1.4	4 3	3.5	5.9	29.1	61 7	15.3	.	15.9
76. Paguringen (*Crataeylon eelebicum*)	1.7	4.6	3.7	8.5	22.5	67.5	19.4	------	18.4
77. Pahutan (*Mangifera altissima*)	1.1	2.4	3.1	4.4	28.2	65.2	17.6	------	15.9
78. Panao (*Dipterocarpus gracilis*)	0.6	6.7	1.6	3.4	27.7[2]	63.4	16.4	------	12.6
79. Paper mulberry (*Broussonetia papyrifera*)	1.6	2.9	2.3	6.0	18.8	74 4	20.7	0.2	20.0
80. Pingkapingkahan (*Oroxylum indicum*)	2.9	3.9	2.4	6.2	32.6	58.3	17.6	.	14.1
81. Potkpot (*Pithecellobium angulatum*)	0.4	13.3	2.2	9.8	27.5	56.3	15.7	------	19.1
82. Red lauan (*Shorea negrosensis*)	0.2	3.3	2.5	5.6	33.8	60.2	10.4	------	13.2
83. Rubber (Para) (*Hevea brasiliensis*)	1.4	2 7	5.5	6.6	20.9	69.5	19.5	----	21.9
84. Sakat (*Terminalia nitens*)	0.4	2.7	6.0	8.4	24.9	64 9	18.6	------	18.7
85. Santol (*Sandoricum koetjape*)	0.9	4.9	6.0	7.9	21.0	67.2	17.6	------	23.0
86. Talisai (*Terminalia catappa*)	1.3	2.0	4.9	5.0	31.3	60.5	17.2	------	17.5
87. Taluto (*Pterocymbium tinctorium*)	1.8	2 2	9.9	11.3	18.9	67 2	16.0	0.03	26.1
88. Tanag (*Kleinhofia hospita*)	1.8	3 2	3.0	4.9	27.7	64 3	17.4	------	15.7
89. Tangile (*Shorea polysperma*)	0.3	4.2	1.9	3.7	31.7[2]	61.9	11.4	.	9.7

[1] Average of 2 samples.
[2] Lignin including ash.

TABLE 2.—*Proximate chemical analyses of some species of Philippine woods*—Continued.

Local and scientific names	Ash	Alcohol-benzene extract	Solubility in hot-water after alcohol-benzene extraction	Solubility in hot-water w/o prior leaching	Lignin	Holocellulose	Pentosans	Silica	Solubility in 1 per cent NaOH
90. Tangisang bayauak (*Ficus variegata*)[1]	4.4	4.2	4.8	9.4	27.3	60.0	15.2	----	21.4
91. Toog (*Petersianthus quadrialata*)	2.5	3.5	0.9	2.5	37.4	55.7	12.7	1.8	17.9
92. Tulo (*Alphonsia philippinensis*)[1]	0.5	3.6	1.0	3.2	23.1[a]	71.8	19.9	----	16.1
93. Vidal's—lanutan (*Bombycidendron vidalianum*)	0.8	4.6	0.7	2.8	26.3	67.8	20.6	----	16.7
94. White lauan (*Pentacme contorta*)	1.1	2.8	1.0	1.9	27.2	67.9	13.3	----	10.3
95. Yakal (*Shorea pisoh*)	1.6	14.1	1.5	9.4	21.4[a]	61.4	14.7	0.03	17.9
Average	1.5	4.2	3.0	6.6	25.7	63.6	16.4	----	16.9

[1] Average of 2 samples.
[a] Lignin including ash.

TABLE 3.—*Proximate chemical analyses of some species of Philippine bamboos.*

(Percentages on oven-dry basis)

Local and scientific names	Ash	Alcohol-benzene extract	Solubility in hot-water after alcohol-benzene extraction	Solubility in hot-water w/o prior leaching	Lignin	Holocellulose	Pentosans	Silica	Solubility in 1 per cent NaOH
1. Bayog (*Dendrocalamus merrillianus*)	4.2	3.6	3.4	6.1	24 2	64.6	23.8	2.1	26.1
2. Boho (*Schizostachyum lumampao*)	9.5	1.7	4.4	5.6	20.6	63.8	21.5	7.5	28.1
3. Giant bamboo (*Gigantochloa aspera*)	4.2	5.8	4.1	6.9	23.5	62.4	20.1	2.1	13.1
4. Kawayan kiling (*Bambusa vulgaris*)	2.4	4.1	5.1	7.8	21.9	66.5	21.1	1.1	27.9
5. Kawayan tinik (*Bambusa spinosa*)	4.8	3.1	4.3	7.0	20.4	67.4	19.0	3.4	39.5
Average	5.0	3.7	4.3	6.7	22.1	64.9	21.1	3.2	26.9

TABLE 4.—*Comparative analyses of the sapwood and heartwood of some Philippine wood species.*

(Percentages on oven-dry basis)

Local and scientific names with sample number	Ash	Alcohol-benzene extract	Hot-water extract (leached)	Hot-water extract (unleached)	Lignin	Holocellulose	Pentosans	Silica	1 per cent caustic soda extract
1. Acasia (*Samanea saman*):									
Sapwood (1-8B)	1.8	7.8	14.0	16.9	19.5	56.9	14.5	.....	29.8
Heartwood (1-8C)	2.1	10.7	2.4	7.5	26.0	58.8	19.1	.....	24.2
2. Agoho (*Casuarina equisetifolia*):									
Sapwood (2-102B)	0.7	1.8	2.2	5.2	26.6	68.7	19.7	.....	13.9
Heartwood (2-102C)	1.1	4.8	1.4	2.5	27.4	65.3	19.2	.....	15.6
3. Anahlong (*Trema orientalis*):									
Sapwood (1-8B)	1.1	3.5	2.1	4.5	22.0	71.3	20.9	.....	18.0
Heartwood (1-8C)	1.7	2.5	1.8	5.7	21.5	72.5	21.5	.....	19.6
4. Anang (*Diospyros pyrrhocarpa*):									
Sapwood (1-25B)	1.7	5.4	1.4	5.1	28.8	62.7	17.2	.....	14.6
Heartwood (1-25C)	4.0	5.3	1.4	5.8	28.8	60.5	17.5	.....	13.6
5. Binggas (*Terminalia comintana*):									
Sapwood (1-23B)	2.0	3.8	3.1	6.3	27.9	63.2	14.3	.....	13.7
Heartwood (1-23C)	5.1	3.3	3.8	6.3	30.7	57.6	12.3	.....	15.7
6. Dagang (*Antiopiera aurea*):									
Sapwood (1-19B)	2.1	4.8	4.8	8.3	24.6	63.7	17.1	1.7	20.6
Heartwood (1-19C)	2.3	5.3	0.9	2.4	26.7	64.8	17.6	1.8	13.8
7. Dangkalan (*Calophyllum obliquinervium*):									
Sapwood (1-9B)	0.5	4.5	2.0	5.8	29.5	63.5	16.2	.....	15.7
Heartwood (1-9C)	0.4	4.3	0.6	1.1	29.9	64.8	15.0	.....	15.7
8. Guijo (*Shorea guiso*):									
Sapwood (3-106B)	0.9	3.5	3.2	4.5	27.3	65.1	18.0	.....	13.9
Heartwood (3-106C)	0.8	4.4	1.0	2.7	28.6	65.2	19.5	.....	16.3
9. Ipil (*Intsia bijuga*):									
Sapwood (1-82B)	1.3	2.8	2.4	3.2	22.0	71.5	20.2	.....	16.8
Heartwood (1-82C)	1.6	10.1	7.8	12.0	22.7	57.8	15.8	.....	25.4
10. Kamagong (*Diospyros discolor*):									
Sapwood (1-61B)	2.1	5.5	2.7	7.0	24.9	64.8	15.7	.....	15.7
Heartwood (1-61C)	2.9	10.8	2.1	4.4	30.4	63.8	18.5	.....	23.5
11. Lanipau (*Terminalia crassirama*):									
Sapwood (1-114B)	1.0	2.1	3.0	4.4	28.5	65.4	4.4	.....	11.3
Heartwood (1-114C)	0.6	2.0	1.8	2.6	30.9	64.7	17.4	.....	11.1
12. Malugai (*Pometia pinnata*):									
Sapwood (2-115B)	1.1	2.5	4.1	5.8	27.4	64.9	5.8	.....	15.0
Heartwood (2-115C)	1.3	3.2	2.1	4.8	21.5	71.9	4.8	.....	16.6
13. Mino (*Dysoxylum euphlebium*):									
Sapwood (1-16B)	1.0	3.3	3.4	7.0	29.1	63.2	16.2	.....	13.8
Heartwood (1-16C)	0.5	11.7	1.8	9.2	33.4	52.6	12.9	.....	18.9
14. Narra (*Pterocarpus indicus*):									
Sapwood (1-98B)	1.3	2.1	1.7	5.1	28.0	66.9	16.8	.....	12.9
Heartwood (1-98C)	1.2	7.3	4.0	7.7	26.3	60.7	14.9	.....	19.0
15. Pahutan (*Mangifera altissima*):									
Sapwood (1-100B)	0.7	2.6	2.7	3.6	26.7	67.3	18.6	.....	14.7
Heartwood (1-100C)	1.3	3.1	5.5	6.1	32.2	57.4	16.5	.....	19.4
16. Talisai (*Terminalia catappa*)									
Sapwood (1-103B)	0.8	2.0	7.9	5.9	29.0	60.3	18.8	.....	16.3
Heartwood (1-103C)	1.4	2.6	2.8	3.3	32.2	61.0	16.7	.....	14.3
17. Toog (*Petersianthus quadrialata*,):									
Sapwood (1-116B)	3.0	4.5	2.5	5.0	29.9	60.1	15.7	.....	19.2
Heartwood (1-116C)	2.6	3.2	1.2	1.9	36.5	56.5	13.1	.....	15.1
18. Vidal's lanutan (*Bombycidendron vidalianum*):									
Sapwood (1-97B)	1.4	2.9	1.7	3.9	25.8	68.2	20.8	.....	15.2
Heartwood (1-97C)	0.7	4.3	0.8	2.5	26.2	68.0	19.6	.....	16.4
Average:									
Sapwood	1.4	3.6	3.6	6.0	26.5	64.9	16.2	.....	16.2
Heartwood	1.8	5.5	2.4	4.9	28.4	61.9	15.9	.....	17.4

TABLE 5.—*Comparative analyses of butt, middle and top portions of logs of some Philippine woods.*

(Percentages on oven-dry basis)

Local and scientific names with sample number	Ash	Alcohol-benzene extract	Hot-water extract after alcohol-benzene leaching	Hot-water extract without prior alcohol-benzene leaching	Lignin	Holocellulose	Pentosans	Silica	Solubility in 1 per cent NaOH
1. Alagasi (*Leucosyke capitellata*) (1-6):									
Butt	3.1	------	------	------	------	------	------	1.6	------
Middle	3.2	------	------	------	------	------	------	1.9	------
Top	4.8	------	------	------	------	------	------	3.6	------
2. Alagasi (*Leucosyke capitellata*) (2-6):									
Butt	2.3	------	------	------	------	------	------	1.2	------
Middle	2.1	------	------	------	------	------	------	1.0	------
Top	2.7	------	------	------	------	------	------	1.5	------
3. Hasselt's-panau (*Dipterocarpus hasseltii*) (1-13):									
Butt	1.2	5.0	1.3	4.1	30.5	62.0	16.6	------	16.6
Middle	0.9	4.8	4.4	5.6	30.0	59.9	15.3	------	15.6
Top	1.0	3.9	2.4	5.9	30.0	60.7	15.6	------	17.0
4. Katilma (*Diospyros nitida*) (1-17):									
Butt	1.5	2.5	1.2	3.0	29.6	65.2	17.3	------	10.0
Middle	1.4	1.9	0.8	2.2	30.0	65.8	17.4	------	9.5
Top	1.6	2.3	1.2	2.7	29.2	65.7	16.9	------	8.8
5. Manggasinoro (*Shorea philippinensis*) (1-10):									
Butt	1.2	6.2	1.3	2.4	27.6	63.7	16.4	1.1	10.2
Middle	0.9	4.4	0.4	0.7	30.1	64.2	16.3	0.8	9.8
Top	1.0	4.6	0.6	2.6	27.6	66.2	16.5	0.9	10.8
Average:									
Butt	1.3	4.[illegible]	1.3	3.2	29.2	63.6	16.8	1.3	12.3
Middle	1.1	3.[illegible]	1.9	2.8	30.0	63.3	16.3	1.2	11.6
Top	1.2	3.[illegible]	1.4	3.7	28.9	64.2	16.7	2.0	12.2

PREPARATION OF SAMPLES

BARK

The bark from the wood discs used for wood analysis (see wood sampling below) was sliced into small pieces, air-dried for a few days, and ground in the laboratory-sized Wiley mill. The ground bark was next screened. About half a kilogram of that portion passing through the 35-mess sieve was used for analysis. This sample was placed in a clean, dry, airtight container completely labelled, numbered, and dated. Samples for analysis were taken from this container from time to time as required.

TABLE 6.—*Comparative analyses of 20 Philippines wood species.*

Scientific name	By the former Bureau of Science [1]				By the Forest Products Research Institute [2]			
	Ash	Hot-water soluble	Lignin	Alkali soluble	Ash	Hot-water soluble	Lignin	Alkali soluble
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1. *Aleurites moluccana* Willd.	2.14	9.64	20.13	21.26	2.2	10.7	27.1	23.6
2. *Bombycidendron sidaliaeum* (Naves)	0.45	2.87	29.46	13.85	0.6	2.8	26 3	16.7
3. *Canonga odorata* (Lam.) Hook. f and Th.	2.51	10.18	23.38	15.97	1.3	7.2	25.9	16.8
4. *Diospyros discolor* Willd.	1.33	8.12	33.66	21.12	2.2	7.0	25.7	17.0
5. *Diplodiscus paniculatus* Turcz.	3.43	5.01	33.36	10.71	3.9	8.9	27.7	21.3
6. *Dipterocarpus grandiflorus* Blanco	0.99	5.07	35.19	16.12	1.5	6.4	28.9	21.2
7. *Drypetes bordenii* Pax and K. Hoffm	1.66	5.70	31.61	16.05	2.0	5.6	28.3	12.8
8. *Endospermum peltatum* Merr.	0.79	7.84	30.83	17.86	1.3	4.2	27.7	15.4
9. *Intsia bijuga* (Colebr.) O. Ktze.	1.25	11.00	32.70	22.44	0.9	8.2	22.6	21.9
10. *Koordersiodendron pinnatum* (Blanco) Merr.	1.07	2.41	33.76	18.43	1.3	5.4	22.1	20.3
11. *Macaranga tanarius* (Linn.) Muell-Arg.	0.98	6.27	32.06	14.66	1.7	9.3	29.8	21.7
12. *Mangifera altissima* Blanco	0.65	5.16	31.23	13 58	1.1	4.4	28.2	15.8
13. *Polyscias pedosa* (Blume) Seem.	0.90	10.29	30.30	24.72	1.5	7.6	23.6	25.0
14. *Pometia pinnata* Forst.	1.36	7.65	37.29	12.50	1.1	6.2	24.9	15.6
15. *Pterocarpus indicus* Willd.	1.05	9.55	31.98	16.92	1.4	5.9	29.1	15.9
16. *Samanea saman* (Jacq) Merr.	0.27	8.86	30.44	19.39	2.4	10.2	25.3	31.9
17. *Sandoricum koetjape* (Burm. f.) Merr.	0.55	6.07	28.71	18.08	0.9	7.3	21.0	23.0
18. *Terminalia catappa* Linn.	0.72	11.05	32.72	18.61	1.3	5.0	31.3	17.5
19. *Terminalia comintana* (Blanco) Merr.	1.80	6.54	35.32	16.35	2.1	5.8	27.6	13.5
20. *Trema orientalis* (Linn.) Blume	1.16	6.63	28.72	20.56	1.6	4.5	22.8	18.6
Average	1.25	7.29	31.15	17.48	1.6	6.7	26.3	19.3

[1] Analysis by Yenko, et al., as reproduced by Reyes. (9)
[2] Data taken from Table 2 above.

WOOD

Plan (*a*).—From a small log specimen available, one disk, or a complete cross section about 1 inch thick, cut from 6 to 12 feet above the ground, was taken. This disk exclusive of bark, was air-dried and later cut into sectors centering on the pith of the log. (Fig. 1)

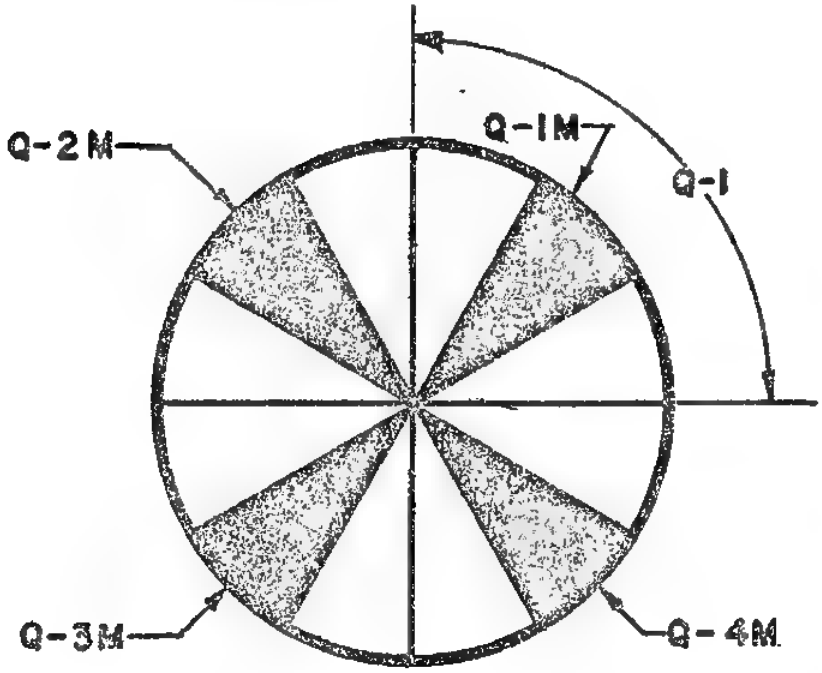

FIG. 1. Diagram of a wood-disk sample.

Q–1 represents the first quadrant of the disk. Q–1M represents the middle one-third portion of the first quadrant. A composite sample was obtained by collecting sectors Q–1M, Q–2M, Q–3M, and Q–4M. These four sectors were sliced, then air-dried and ground in the Wiley mill. The general material passing through the 35-mesh sieve and retained on the 60-mesh sieve was used as the sample for the chemical analysis.

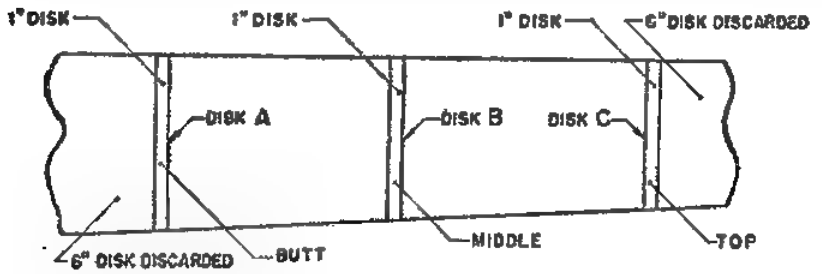

FIG. 2. Diagram of log showing butt, middle, and top portions from which disks were taken.

Plan (*b*).—If sufficient time was available for analysis and the log specimen was big, say over 24" in diameter by 20 feet long, cutting three disks or cross sections, 1" thick each, one from the butt, one from the middle, and one from the top, was preferred. (Fig. 2). The respective quadrants—northern, western, southern, and eastern—were marked and each quadrant was divided into three sectors, such as A_1, C_1, and E_1 (Fig. 3). One sector, exclusive of the bark, from each of the three disks was taken to represent a composite sample and was air-dried and ground for analysis.

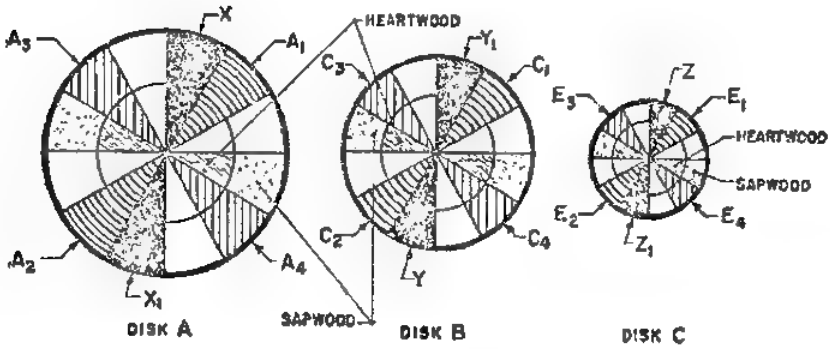

Fig. 3. Diagrams of disks from log showing sectors and their sapwood and heartwood portions used for analyses.

As a general rule, representative sectors or segments sufficient to provide at least half a kilogram of wood, air-dry basis, were selected and ground in a Wiley laboratory mill to pass a 35-mesh sieve but to be retained on the 60-mesh sieve. Samples thus obtained were stored in airtight glass containers, completely labelled, numbered, and dated. Parts of these samples were used for chemical analysis and the rest retained for future use as needed. A card record of each sample was also prepared with dates, giving complete information about the sample and the results of all the tests that were subsequently made upon it.

Other sectors from the same quadrant or from other quadrants, for that matter, were not analyzed. As stated above, Yenko, et al, many years ago, conducted analyses on sections of the sapwood, heartwood, and core of both small and medium sized bagtikan trees (*Parashorea malaanonang*). "Their analysis showed that corresponding sections of these trees gave similar results for the chief constituents. From these data it was

assumed that any sound mature tree, whether small or medium-sized, shall give average representative samples."

BAMBOO

From the air-dried bamboo chips intended for pulping studies, a representative sample, about 0.5 kilogram, was taken, ground in the Wiley mill, and dealt with following essentially the same procedure discussed on the bark.

PROCEDURE

In the general (exploratory) chemical survey by the Forest Products Research Institute, the following determinations were made using the appropriate standard methods of the Technical Association of the Pulp and Paper Industry (TAPPI) (12) indicated after each:

Group to be determined	TAPPI Standard
(1) Ash	*T* 15 m–54
(2) Alcohol-benzene extract	*T* 6 m–54
(3) Hot water extract (after alcohol-benzene leaching)*	*T* 1 m–54
(4) Lignin (in extracted sample)	*T* 13 m–54
(5) Total pentosans	*T* 19 m–50
(6) Approximate holocellulose (by difference), that is, holocellulose = [100 — (1 + 2 +3 + 4)]	
(7) Silica in ash	
(8) Solubility in 1 per cent hot caustic soda solution	*T* 4 m–54

The analysis of each bark, wood, and bamboo sample was made in duplicate, at least, and the arithmetical averages are reported in Tables 1 to 4, and 6.

ANALYSIS OF BARK

Only ash, alcohol-benzene, and hot-water extractions were made. The method of analysis for ash and alcohol-benzene extraction employed for barks were the same as the ones used for wood or bamboo discussed below.

For hot-water extraction of bark, a modified method (19) was used. Two grams, oven-dry basis, of the bark meal was

* It was found that in a sample of wood, there was a great difference between the amount of the hot-water extract after leaching with alcohol-benzene and the hot-water extract without prior leaching with alcohol-benzene. The hot-water extract, after alcohol-benzene extraction, did not give a true picture of the amount of water-soluble extractives in the wood. Therefore, both kinds of hot-water extractions were made and reported in this study.

placed in an Erlenmeyer flask; 100 cc hot water (90°C) was added and the mixture heated on a sand bath with frequent shaking, maintaining the solution level in the flask by adding hot water every now and then. After two hours' heating, the liquid was decanted into a tared beaker, and another 100 cc of hot water was added to the flask. The heating on the sand bath was continued for another 2 hours, then the mixture was filtered and washed again into the tared beaker. The combined filtrates and washings were evaporated to dryness and the weight of residue represented the hot-water extract.

$$\text{Wt. of hot-water extract} = \text{gross wt. of beaker} - \text{tared wt. of beaker}$$

$$\text{Per cent hot-water extract} = \frac{\text{wt. of hot-water extract in gms}}{2} \times 100$$

ANALYSIS OF WOOD

Ash.—The ash represents all the nonvolatile, noncombustible portions of the wood. This includes silica (Sio_2), salts of calcium, manganese, potassium, and other inorganic nonvolatile compounds that may be present.

Two grams, based on oven dry weight, of the wood meal sample was placed in a tared porcelain crucible and heated in the muffle furnace at 600°C for one day. Then the crucible and content were placed in a desiccator, cooled to room temperature, and weighed. The procedure was repeated until constant weight was obtained.

$$\text{Wt. of ash} = \text{gross wt. of crucible} - \text{tared wt. of crucible}$$

$$\text{Per cent ash} = \frac{\text{net wt. of ash in gms}}{2} \times 100$$

Alcohol-benzene solubility.—According to TAPPI(12) this is a measure of the waxes, fats, resins, and certain other ether-soluble components, including possibly some so-called wood gums. This is determined by leaching the wood under standardized conditions with a solvent consisting of 33 parts by volume of 95 per cent ethyl alcohol and 67 parts by volume of C.P. benzene. This solvent mixture dissolves the constituents of wood, such as oils, resins, waxes and other organic compounds, that are soluble in it. In general it does not remove the water-soluble constituents, such as tannins or gums, although it is probable that some constituents soluble in alcohol-benzene mixture are also soluble in water.

Two grams, oven-dry basis, of wood meal sample was placed in an alundum crucible and extracted with 200 cc of the

alcohol-benzene mixture for 8 hours using a Soxhlet extraction apparatus (Plate 1). The extract in the tared flask, after recovering the alcohol-benzene solvent by distillation, was evaporated to dryness. The flask and contents were weighed to constant weight.

$$\text{Per cent alcohol-benzene solubility} = \frac{\text{Net wt. of residue in flask in gms}}{2} \times 100$$

Hot-water extract (without alcohol-benzene extraction).—Two grams, oven-dry basis, of composite wood meal sample was placed in a 250 cc. Erlenmeyer flask and to this was added 100 cc hot water (95°C). The mixture was digested for 8 hours in a water bath in which the water outside the flask was maintained at the same level as the liquid inside the flask. It was then filtered through a fritted glass crucible of medium porosity into a tared beaker and washed little by little with 100 cc hot water. The filtrate and washings were evaporated to dryness in the tared beaker and weighed to constant weight.

$$\text{Gross wt. of beaker} - \text{tared wt. of beaker} = \text{wt. of hot-water extract}$$

$$\frac{\text{Wt. of hot-water extract in gms}}{2} \times 100 = \text{per cent hot-water extract}$$

Hot-water extraction (sample previously leached with alcohol-benzene).—The residue in the alundum crucible, after the alcohol-benzene extraction, was the one used in this instance for hot-water extraction, instead of the unleached, fresh, wood-meal sample. This residue was transferred to an Erlenmeyer flask and the rest of the analysis was essentially the same as in the method immediately preceding.

Lignin.—Lignin is the nonfibrous cementing substance of the wood and usually constitutes about one-fourth to one-third of the dry wood substance. It is determined by first removing all substances soluble in alcohol (the cathechol tannins), alcohol-benzene (the resins, oils, fats, and waxes), hot water (the remaining water soluble materials), and 72 per cent sulfuric acid (carbohydrates).

For woods known to be high in tannins, the alcohol extraction is necessary. However, in this study the alcohol extraction was omitted.

The residue from the sample previously extracted with alcohol-benzene and hot-water was treated in a 50 cc beaker with 30 cc

72 per cent H_2SO_4 for 2 hours at 18° to 20°C with occasional stirrings. Then it was transferred to a big beaker and diluted to 1,200 cc. It was then boiled for 4 hours maintaining the level of the solution inside the beaker by adding hot water now and then. It was filtered the next day under suction through a tared gooch crucible lined with asbestos fiber, then washed with 500 cc hot water until free of acid. Then the crucible and its contents were dried to constant weight. Next, the contents of the gooch crucible were ashed to constant weight. The difference in weight before and after ashing represented the weight of the lignin.

$$\text{Per cent lignin} = \frac{\text{wt. of the lignin in gms}}{2} \times 100$$

Total pentosans by the gravimetric method.—Pentosans are a part of the noncellulose carbohydrates (hemicelluloses) in wood, chiefly consisting of xylan and araban, which are converted to furfural with strong hydrochloric acid.

One and a half (1.5) grams of composite wood meal sample, based on oven dry weight, was placed in a 300-cc Florence flask. A small piece of sliced paraffin was added to eliminate foaming and a few glass beads, to prevent bumping. Next, 100 cc of 12 per cent HCl was added, the flask placed on a wire gauze, connected to a condenser, heated gently over the Bunsen burner, regulated so as to distil over 30 cc in 10 minutes. The distillate was passed through a small filter paper before it entered the receiver, keeping the tip of the condenser as close as possible to the filter paper.

As soon as 30 ml of distillate was collected, another 30-cc portion of 12 per cent HCl was added from the separatory funnel in such a way as to wash down particles adhering to the inner sides of the flask. This method of distillation was continued until 360 cc of distillate was collected in the receiving flask. To the total distillate in the receiving flask, 40 ml of filtered phloroglucinol solution that had been prepared at least a week previously was added gradually with stirring. The distillate soon turned greenish black. The solution was allowed to stand for 16 hours, during which time the amorphous black precipitate of furfural phloroglucide settled on the bottom of the beaker. The clear supernatant liquid was then tested with aniline acetate paper. If the paper did not turn pink, it in-

dicated that precipitation was complete; otherwise, more of phloroglucinol solution was added and the mixture again allowed to stand for 16 hours.

The precipitate, furfural phloroglucide, was collected in a weighed gooch crucible having a thick asbestos mat. The precipitate was washed with exactly 150 ml of cold water in such a way that the water was not entirely removed from the crucible until the washing was completed. The crucible was then dried for two and one-half hours in the oven at 100° to 105°C, cooled in a tared stoppered weighing bottle and weighed. This process was repeated until constant weight was attained. The increase in weight was considered to be furfural phloroglucide.

The weight of pentosans corresponding to the weight of furfural phloroglucide was found as follows:

$$\text{Pentosans} = (a + 0.0052) \times f$$

where a = wt. of furfural phloroglucide in gms
and f = 0.895 if a is less than 0.03 gm
— 0.887 if a is between 0.03 and 0.3 gm
— 0.882 if a is more than 0.3 gm

$$\text{Per cent pentosans} = \frac{(a + 0.0052) \times f}{1.5} \times 100$$

Silica (SiO_2) in ash.—Only species analyzing 1.5 per cent or more in ash were further analyzed for their silica contents.

Ten grams of wood meal, oven-dry basis, was placed in a tared platinum crucible and 5 cc concentrated H_2SO_4 added to moisten the meal thoroughly. The crucible was then heated on the hot plate in the chemical hood to drive off excess H_2SO_4 after which it was ashed in the muffle furnace at 600°C until constant weight was attained. One or two drops of concentrated H_2SO_4 and 5 cc concentrated H_2F_2 were next added and the crucible and contents were again heated in the chemical hood and finally in the muffle furnace at 600°C until constant weight was obtained. The weight of silica (SiO_2) was the difference between the weight of the ash before and after treatment with H_2F_2.

$$\text{Per cent silica } (SiO_2) = \frac{\text{wt. of silica in gms}}{10} \times 100$$

Caustic soda (NaOH) solubility.—Wood solubility in 1 per cent NaOH solution reflects the degree of fungus decay in wood.

As wood decays, the percentage of alkali-soluble material increases in proportion to the decrease in pulp yield caused by the decay.

Two or three grams of composite wood meal sample, oven-dry basis, was placed in a 150 cc beaker and 100 cc or 1 per cent NaOH added. The mixture was digested for 1 hour at 90° to 95°C in a water bath, periodically stirring the mixture at 10, 15, and 25 minutes after placing the beaker in the bath. After digestion, the mixture was filtered through a tared fritted glass crucible, washed with 50 cc 10 per cent CH_3COOH and then thoroughly washed with hot water. The fritted glass and contents were dried in the oven, cooled to room temperature, and weighed. The drying was repeated until constant weight was attained.

a = gross wt. of fritted glass − tared wt. of fritted glass = wt. of residue

$$\frac{\text{(Original wt. of sample} - a)}{\text{Original wt. of sample}} \times 100 = \text{per cent solubility in 1 per cent NaOH}$$

ANALYSIS OF BAMBOO

The methods employed in analyzing bamboo were the same as the ones used for wood.

RESULTS AND DISCUSSION

The results obtained in these studies are shown in Tables 1 to 4, and 6.

Table 1 shows the proximate chemical analyses of the barks of 60 Philippine woods.

Table 2 shows the proximate chemical analyses of 95 species of Philippine woods.

Table 3 shows the proximate chemical analyses of five species of Philippine bamboos.

Table 4 shows the comparative analyses of the sapwood and heartwood of 18 Philippine wood species.

Table 5 shows the comparative analyses of the butt, middle, and top portions of the logs of four Philippine wood species.

Table 6 shows the comparative analyses of 20 Philippine wood species by the former Bureau of Science and the present Forest Products Research Institute.

COMPARATIVE ANALYSES

Bark and wood.—The bark showed consistently higher percentages of ash and extractives than the wood (Tables 1 and 2). On the average, the bark registered more than six times

the percentage of ash found in the wood, almost twice in alcohol-benzene extract and about three times in hot-water solubility.

The higher ash content of the bark may be due in part to the collection of air-borne dust, but the extent of this was not studied.

Bamboo and wood.—The bamboos, on the average, showed higher percentages of ash, silica, hot-water extractive, pentosan, and holocellulose as well as higher solubility in one per cent NaOH solution. Wood, on the other hand, registered higher percentages of alcohol-benzene extractive and lignin. (Tables 2 and 3)

It may be pointed out in this connection that, other factors remaining the same, the bamboos may be easier to pulp than the woods because bamboo contains less lignin than wood. Pulping and bleaching are mainly processes of delignification.

On the other hand, for purposes of manufacturing dissolving pulps, the woods are better raw materials than the bamboos. These two components, however, offer great difficulty in the purification of the pulp.(7)

Heartwood and sapwood.—From Table 4, it can be seen that the sapwood averaged a greater quantity of extractive than the heartwood by about 50 per cent after alcohol-benzene leaching, and by about 20 per cent without prior alcohol-benzene leaching. On the other hand, the heartwood averaged higher contents of ash and alcohol-benzene extractive, by 28 per cent and 53 per cent, respectively, than the sapwood. The percentage differences were not substantial for the other components analyzed.

Butt, middle, and top portion of the log.—A comparison of the analyses of the butt, middle, and top portions of the logs analyzed (Table 5) shows that, in the main, there is no substantial difference in the analyses of these parts of the log except in the alcohol-benzene extractive in the butt, which is higher than those in the middle and top by about one-fourth. In ash, pentosan, and holocellulose contents, as well as in hot-water solubility, there is no substantial difference.

THE BARKS

Of the barks reported herein, that of apitong (*Dipterocarpus grandiflorus*) gave the highest percentage of ash, 31.7 per cent compared with 9.3 per cent, the average for the sixty species analyzed. Cinchona (*Cinchona succirubra*) registered the highest (29.0 per cent) alcohol-benzene solubility, the average

for the sixty barks analyzed being 7.5 per cent. In the case of hot-water extraction without prior alcohol-benzene leaching, alagasi (*Leucosyke capitellata*) gave the highest percentage, 33.0 per cent, as compared with 16.3 per cent, the average for the 60 barks studied.

THE WOODS

Ash content.—Among the 95 wood species analyzed (Table 2), three tied for the lowest percentage (0.2 per cent) in ash content, namely, casia (*Cassia spectabilis*), mayapis (*Shorea squamata*), and red lauan (*Shorea negrosensis*); while dolalog (*Ficus integrifolia*) registered the highest (6.5 per cent).

Alcohol-benzene solubility.—Igem (*Podocarpus javanicus*) gave the lowest percentage (0.2 per cent) while cinchona (*Cinchona succirubra*), the highest (15.9 per cent).

Hot-water solubility (without prior alcohol-benzene leaching).—Igem (*Podocarpus javanicus*) gave the lowest (0.5 per cent) while kapok (*Ceiba pentandra*), the highest (12.0 per cent).

Hot-water solubility (without prior alcohol-benzene leaching).—Igem registered the lowest (1.1 per cent) and kapok, the highest (14.2 per cent).

Lignin content.—Magtungan (*Syzygium alcinæ*) gave the lowest (17.5 per cent) while alagasi (*Leucosyke capitellata*), the highest (34.4 per cent), including ash in lignin.

Holocellulose content (determined by difference).—Toog (*Petersianthus quadrialata*) registered the lowest (55.7. per cent) while paper mulberry (*Broussonetia papyrifera*), the highest (74.4 per cent).

Pentosan content.—Igem gave the lowest (9.8 per cent) and malapapaya (*Polyscias nodosa*) the highest (24.7 per cent).

Silica content.—Among those analyzed for silica, malubago (*Hibiscus tiliaceus*) gave the lowest (0.0 per cent) while alagasi and toog (*Petersianthus quadrialata*) tied for the highest (1.8 per cent).

Solubility in one per cent NaOH solution.—Tangile (*Shorea polysperma*) registered the lowest (9.7 per cent) and acacia (*Samanea saman*), the highest (31.9 per cent).

With reference to Table 5, there appear, on the average, slight differences in the analyses of twenty Philippine woods as done by the former Philippine Bureau of Science (now

Institute of Science and Technology) and the Forest Products Research Institute. These differences might be attributed to:

1. difference in sampling
2. identification of species
3. details of methods of analysis used, and
4. normal variation from one tree to another of the same species. (No two individual trees, even of the same species, are exactly identical in all respects).

THE BAMBOOS

Of the five bamboo species analyzed in this experiment, boho (*Schizostachyum lumampao*) registered the highest percentage of ash and silica contents. (Table 3)

SUMMARY AND CONCLUSIONS

Some 60 Philippine barks were analyzed for ash and their solubilities in alcohol-benzene and hot-water. (Table 1)

Five bamboo, 93 hardwood, and 2 softwood species growing in the Philippines were analyzed to determine their contents of ash, lignin, holocellulose, pentosans, and their solubilities in alcohol-benzene, hot-water, and 1 per cent sodium hydroxide solution. Those species giving 1.5 per cent or more in ash were further analyzed for their silica content. (Tables 2 and 3)

Comparative analyses were performed on the heartwood and sapwood of 18 and on the butt, middle, and top portions of 5 Philippine wood species. (Tables 4 and 5)

The results, as shown in Tables 1 to 5, bring out the following:

1. Compared with some American hardwoods(13) the Philippine species dealt with in this experiment show, on the average, lower percentages of hot-water extractives, lignin, and pentosans. Wise(15) mentioned that woods from the Philippines and British North Borneo, as explored by Miura, are relatively low in pentosans compared with American woods.

2. With the hardwood species analyzed in this study, lignin, on the oven-dry basis, is, on the average, one-fourth of the whole wood substance exclusive of the bark while holocellulose (determined by difference) is a little less than two-thirds of the wood excluding bark.

3. Bamboos appear in general to have higher contents of ash, silica, and pentosans than woods.

Philippine hardwoods have, in general, higher lignin and extractive contents than American hardwoods.

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ILLUSTRATIONS

PLATE 1

A battery of Soxhlet extraction apparatus. Fig. *a*, Watercooled vapor condenser; *b*, Tared alundum crucible containing wood meal sample; *c*, Soxhlet extraction tube; *d*, Tared flask; *e*, Alcohol-benzene solvent; *f*, Hot plate.

TEXT FIGURES

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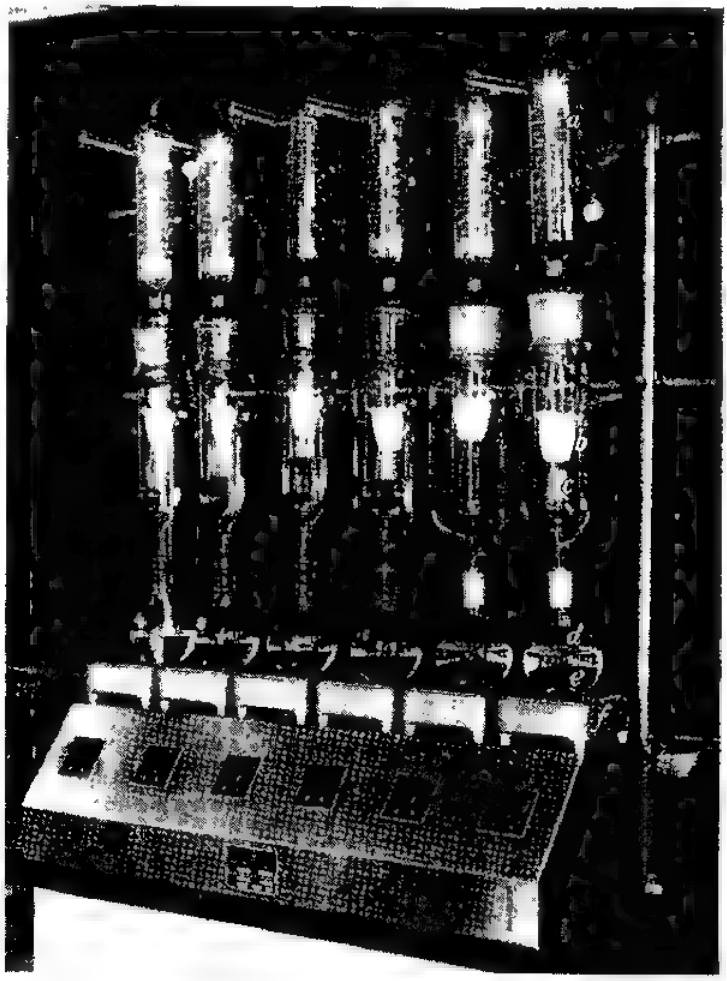

PLATE 1.

COMPARATIVE STUDY OF THE CELLULOSE CONTENT OF THE TRUNKS OF DIFFERENT VARIETIES OF BANANAS

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In the Philippines millions of trunk or stems of the banana plant (*Musa sapientum* L.) are left to rot after the fruit is harvested. Attempts to discover a way for their large-scale utilization have been made. The fact that abaca (*Musa textilis*) fibers make good material for paper suggests the possibility of the manufacture of paper from banana stem fibers. An earlier investigation along this line—on leaves and petioles—has been reported.(5) The present study is limited to the fibers of the stems of Philippine bananas.

According to Merrill,(4) there are about 37 varieties of banana plants found in the Philippines. Richmond(6) cites Mariano Vivencio as having made a chemical analysis of the local banana plant and found that it contains 2.21 per cent crude fiber, which is comparable to the 2.9 per cent found in abaca.

In studying their suitability as source of material for paper and allied products, a comparative analysis was made of the cellulose content of the outer, middle, and inner portions of the whole stems of 13 of the most common and popular varieties of Philippine bananas. These are the latundan [M. *cinerea* Blanco], saba [*M. compressa* (Blanco) Teodoro], galamai-señora [*M. glaberrima* (Blanco) Teodoro], sabang Iloko [*M. grandis* Teodoro], lacatan [*M. lacatan* (Blanco) Teodoro], buñgulan [*M. suaveolens* (Blanco) Teodoro], gloria [*M. ternatensis* (Blanco) Teodoro], morado [*M. violacea* (Blanco) Teodoro], dinalaga [*M. dinalaga* var.], raines-na-puti [*M. raines* var.], sicsec [*M. sicsec* var.], tombak [*M. tombak* var.], and butuan [*M. errans* Blanco var. *botoan*]. The samples of the *glaberrima, lacatan,* and *ternatensis* varieties were taken from Tagaytay City. Samples of the raines, sicsec, tombak, and butuan varieties were obtained from Lukban, Quezon Province. The remaining six samples were taken from the Institute of Science premises.

PROCEDURE

The trunks or stems of these samples were cut into thin slices, dried under the sun, then powdered to pass a 50-mess sieve and kept in labelled and stoppered bottles for analysis. The general quantitative scheme for the valuation of the fibrous material was done after Cross and Bevan.(2) The ash, alkali hydrolysis, and the cellulose were computed on moisture-free basis.

RESULTS AND DISCUSSION

Results of the analysis on the outer, middle, and inner portions of the banana stems are given in Table 1.

TABLE 1.—*Valuation of cellulosic material of banana trunks.*[1]

I = Outer portion
II = Middle portion
III = Inner portion

Local and scientific names	Moisture			Ash[2]		
	I	II	III	I	II	III
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1. Latundan (*M. cinerea* Blanco)	8 91			19.00		
2. Saba (*M. compressa* Blanco)	8.42	6.88	11.30	21.23	25.07	23.88
3. Galamai señora (*M. glaberrima* var.)	7.12			11.54		
4. Sabang Loko (*M. grandis* Teodoro)	11.20	7 12	12 57	17.01	16.54	30.23
5. Lacatan (*M. lacatan* (Blanco) Teodoro)	6.40	7.99	13.20	28 08	20.37	39 89
6. Buñgulan [*M. suaveolens* (Blanco)]	10.82	9.52	13.43	20.22	13.14	22 43
7. Gloria [*M. ternatensis* (Blanco) Teodoro]	6.64	8.39	12.41	20 61	23.19	42.52
8. Morado (*M. violacea* Blanco)	11 03	9 12	13 08	21.57	24.17	26.43
9. Dinalaga (*M. dinalaga* var.)	7.90	7 86	8 35	21 30	25.25	17.67
10. Raines-na-puti (*M. raines* var.)	9.74	9 29	10 33	27 84	26.29	22.67
11. Siesec (*M. sacee* var.)	8.18	9.51	12 59	21 89	19.82	20.77
12. Tombak [*M. tombak* (Blanco) Teodoro]	5.14	5.74	8.08	25.59	27.13	25.53
13. Butuan (*M. boloan* var.)	9.33	7.23	9.21	16.94	5.70	6.80

Local and scientific names	Loss in 5 minutes with 1 per cent NaOH hydrolysis[2]			Loss in 1 hour with 1 per cent NaOH hydrolysis[2]		
	I	II	III	I	II	III
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1. Latundan (*M. cinerea* Blanco)	59.41			69.39		
2. Saba (*M. compressa* Blanco)	62.78	67.85	85.41	72 50	74.33	88.13
3. Galama, señora (*M. glaberrima* var.)	41.96			55 97		
4. Sabang Loko (*M. grandis* Teodoro)	66.83	66.34	85 81	76 66	71 89	92 22
5. Lacatan [*M. lacatan* (Blanco) Teodoro	59.92	55.90	82 54	69.76	65 90	90.01
6. Buñgulan [(*M. suaveolens* (Blanco.]	61.96	65.72	89.34	74.90	74.55	93.03
7. Gloria [*M. ternatensis* (Blanco) Teodoro]	46.83	68.80	87.78	57.24	80.88	92.69
8. Morado (*M. violacea* Blanco)	57.14	64.13	70.07	70 55	70 64	80.07
9. Dinalaga (*M. dinalaga* var.)	60.85	65.82	64.49	69 23	72 90	76.08
10. Raines-na-puti (*M. raines* var.)	58.20	72.74	67.41	70 51	89 72	81.54
11. Siesec (*M. sacee* var.)	57.42	61.08	78.71	68.43	74.05	88.30
12. Tombak [*M. tombak* (Blanco) Teodoro]	49.69	56.60	60.69	59.57	65.47	71.54
13. Butuan (*M. boloan* var.)	54.38	78.67	77.25	67 81	84.13	86.75

[1] After Cross and Bevan.
[2] Percentage on moisture-free basis.

TABLE 1.—*Valuation of cellulosic material of banana trunks*[1]—Continued.

I = Outer portion
II = Middle portion
III = Inner portion

Local and scientific names	Differences (b-a)			Cellulose[2]		
	I	II	III	I	II	III
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1. Latundan (*M. cinerea* Blanco)	9.98			30 92		
2. Saba (*M. compressa* Blanco)	9.72	6.48	2.72	30.66	31.25	19.59
3. Gulamai señora (*M. glaberrima* var.)	14.01			33.96		
4. Sabang Iloko (*M. grandis* Teodoro)	9.83	5.43	6.41	30.16	29.38	19.29
5. Lacatan (*M. lacatan* (Blanco) Teodoro)	8.84	10.60	7.67	39 10	38 93	22.03
6. Buñgulan [(*M. suaveolens* (Blanco)]	12.08	8.83	3.69	27.22	29 60	19.18
7. Gloria [(*M. ternatensis* (Blanco) Teodoro)]	10.41	12.08	4.82	36.83	31.84	20.52
8. Morado (*M. violacea* Blanco)	13.41	6.51	10.02	32.23	35.09	31.09
9. Dinalaga (*M. dinalaga* var.)	8.38	7.08	11.59	29.72	27.99	26.09
10. Raimes-na puti (*M. raimes* var.)	12.31	16.98	14 13	31 57	31 29	20.02
11. Siesec (*M. siesee* var.)	11.01	12.07	9.56	33 39	32.53	22.66
12 Tombak [(*M tombak* (Blanco) Teodoro]	9.88	8 87	10.85	38.60	32.98	32.14
13. Butuan (*M. botoca* var.)	19.43	6.26	9.50	32.57	17.44	14.01

Local and scientific names	Cellulose fibers								
	Length			Diameter			Ratio		
	I	II	III	I	II	III	I	II	III
	mm	*mm*	*mm*	*mm*	*mm*	*mm*			
1. Latundan (*M. cinerea* Blanco)	1.40	----	----	0.014	----	----	105	----	----
2. Saba (*M. compressa* Blanco)	1.84	1.76	1.55	0.014	0.014	0.012	132	125	123
3. Gulamai señora (*M. glaberrima* var.)	1.63	----	----	0.014	----	----	116	----	----
4. Sabang Iloko (*M. grandis* Teodoro)	1.85	1.69	1.55	0.014	0.014	0.013	132	115	124
5. Lacatan [*M. lacatan* (Blanco) Teodoro]	1.65	1.65	1.40	0.014	0.014	0.012	117	118	112
6. Buñgulan [*M. suaveolens* (Blanco)]	1.92	1.65	1.61	0.014	0.014	0.013	137	118	128
7. Gloria [(*M. ternatensis* (Blanco) Teodoro)]	1.85	1.46	1.47	0 014	0.014	0.011	131	104	129
8. Morado (*M. violacea* (Blanco)	1.72	1.50	1.56	0 014	0.014	0.013	136	108	119
9. Dinalaga (*M. dinalaga* var.)	1.66	1.56	1.40	0.014	0.014	0.012	118	111	110
10 Raimes-na-puti (*M. raimes* var.)	1.85	1.57	1.40	0.014	0.014	0.013	132	112	104
11. Siesec (*M. siesee* var.)	1.84	1.58	1.44	0.014	0.014	0.013	131	113	114
12. Tombak [(*M. tombak* (Blanco) Teodoro)]	1.85	1.66	1.40	0 014	0.014	0.012	131	118	115
13. Butuan (*M. botoan* var.)	1.84	1.79	1.54	0.014	0.014	0.012	131	128	126

[1] After Cross and Bevan.
[2] Percentage on moisture-free basis.

Moisture content.—The average moisture content of the fibrous material of the stem was 7.95 per cent for the outer portion, 7.91 per cent for the middle, and 10.4 per cent for the inner. These give a general average of 9.9 per cent moisture, which is deemed satisfactory, considering that high class textile fibers have from 6 to 12 per cent moisture in their cellulose.(5)

Ash content.—The table shows, on the other hand, that the material possesses an unsatisfactory high ash content. The averages are 23.19 per cent for the outer, 23.77 per cent for the middle, and 23.5 per cent for the inner portions. This high ash content is directly proportional to the absorption of methylene blue.(5) Normally, cellulose has low absorptive power for methylene blue. The presence of high ash may be attributed to the mineral content of the material analyzed.

Alkali solubility.—The percentage of the substance removed by the solvent action of (*a*) 1 per cent soda treatment for 5 minutes increases on average from the outer portion, 56.16 per cent; to middle, 64.56 per cent; and to inner, 76.2 per cent. Refluxing with (*b*) the same strength of soda for one hour has also an increasing "degrading" action besides the solvent action. The averages are 67.06 per cent for the outer, 74.03 per cent for the middle, and 87.35 per cent for the inner portions. The difference of (*a*) and (*b*) value (in the outer portion averaging 10.9 per cent; the middle, 9.44 per cent; and the inner, 8.16 per cent) indicates the susceptibility of the fiber substance to be attacked by the alkali.(2)

The high alkali solubility shows that only moderate yields of pulp can be produced from banana fibers by the soda process.

Fiber size.—Under the microscope, the ultimate fibers appear as smooth cylindrical cells, with uniform diameter and rather blunt end formations. The sizes of the fibers were determined by the use of standardized ocular micrometer under x 42 magnification. Measurements of the fibers from various portions of the stem are as follows:

	Ave. length mm	Diameter mm	Ratio
Outer portion of the stem	1.76	0.014	126
Middle portion of the stem	1.62	0.014	115
Inner portion of the stem	1.48	0.012	118

These sizes correspond to data in Chittenden and Coomber's study(1) on dried banana leaves and petioles, which have 1.33 mm average cell length and 0.02 mm average cell diameter.

Fibers from banana stem may be classified as short-to-medium material which would yield pulp of moderate strength only. However, if blended with abaca fiber waste, these would probably make paper of higher strength. According to a report,(3) London firms confirmation had verified that paper made with 100 per cent abaca fiber is stronger than that manufactured with 100 per cent craft.

Cellulose content.—The cellulose content is fairly low. As shown in the table, the cellulose content of the outer portion is between 27.22 per cent and 38.6 per cent; of the middle, between 27.99 per cent and 38.93 per cent; and of the inner, between 19.18 per cent and 32.14 per cent. Their averages are 32.11 per cent for the outer, 32.13 per cent for the middle, and 23.26 per cent for the inner. These averages fall below the average which Chittenden and Coomber(6) found in dried banana leaves and petioles, which was 38.0 per cent (ash-free, and moisture-free basis).

However, since banana stem fibers are ready for chemical treatment, the soda treatment may be substituted by extracting and bleaching with 5 per cent sodium bicarbonate solution, which can be used repeatedly, three or more times, and with 5 per cent of lime solution.(5) The cheapness of the process of extraction of the pulp and the consequent low investment in installation of extraction and pulping machines will compensate for the low content of cellulose in banana stems. Banana fibers can be disintegrated and pulped so easily and cheaply that they become one of the most economical materials for paper making.(5)

SUMMARY

The trunks of 12 different varieties of *Musa sapientum* and one variety of *Musa errans* were analyzed for possibility of utilizing the cellulose content for paper making. The results of the comparative studies of the outer, middle, and inner portions are in Table 1.

The moisture content of the three portions of the stem was found satisfactory, being within the limits of those of high class textile fibers.

Their ash content is rather high. Normal ash content is from 3 to 6 per cent. They were also found to have high alkali solubility when the soda process was applied, giving a low yield in cellulose and, consequently, of pulp.

The fibers are smooth cylindrical cells, short-to-medium size, with uniform diameter. These would yield pulp of moderate strength only.

On the basis of findings of Chittenden and Coomber on dried banana leaves and petioles (moisture, 8.4 per cent; cellulose, 38.0 per cent; alkali solubility, immersion in 1 per cent NaOH for 1 hour, 29.1 per cent; average length of fibers, 1.33 mm; average diameter, 0.2 mm) and of Cross and Bevan on Esparto grass (moisture, 9.38 per cent; cellulose, 48.25 per cent; length of fiber, 1.5 mm; diameter 0.012 mm; ratio, 125), which were found suitable for paper making, our findings on banana stem fibers show that these also can be considered suitable material for the same purpose. Their short-to-medium length is specially well adapted, however, for the manufacture of tissues and mimeograph stencils.

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ANALYSIS AND COMPOSITION OF NANKA (ARTOCARPUS INTEGRA MERR.) LATEX

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ONE PLATE AND ONE TEXT FIGURE

The jackfruit or *nanka* (*Artocarpus integra* Merr.) is cultivated throughout the Philippines and is well known for its latex content as well as for its delicious fruit. The flesh of the young fruit makes a very palatable dish when cooked and eaten as a vegetable. The exudate or latex is used for caulking boats, cementing broken china, trapping birds, and, by some persons, as chewing gum.

C. D. Mell[1] writes about this tree:

> The jackfruit tree, a native of the Indian archipelago, is now widely grown throughout the tropics. Under normal conditions it may attain an age of several hundred years and measure 70 to 80 feet in height and over 3 feet in diameter near the base. The jackfruit tree, as well as the breadfruit tree (*A. incisa*), readily recovers from the severest pruning or misuse. The fruits not required for human consumption are used for fattening cattle and sheep. Young branches are also used for feeding sheep and cattle especially during dry seasons when fodder is scarce. When the thick bark is cut, an abundance of a thick white fluid exudes which is used in India and Brazil as a rubber substitute. In Brazil both bark and leaves are used for medicinal purposes. The wood is very durable and valuable for carpentry, furniture, etc., though only the hardwood can be used for this purpose, the sapwood being soft and useless. The heartwood also contains a brilliant yellow dye similar to that of the fustic tree to which the jackfruit tree is closely related.

This study of the latex of the nanka fruit or jackfruit, which forms part of a long-range investigation of Philippine natural resins, was undertaken in order to determine its contituents, especially its resinous content.

EXPERIMENTAL PROCEDURE

The samples used in this investigation were furnished the Institute of Science and Technology, Manila, by Dr. Alfredo P. Magpantay from fruits grown in his plantation in Batangas Province.

[1] Bull. Pan Amer. Union 51 (1920) 605.

Four nanka fruits about 3 or 4 months old were used. They were each cut into six longitudinal sections with a sharp native bolo. All the edible portions, especially those with seeds, were removed by hand. The undeveloped tenuous filaments or strands were shaved off and the rind was pressed with a firm fork to release the exudate or latex. This was collected and kept in a refrigerator to prevent discoloration.

Despite much care taken in extracting the latex, it still was found to contain impurities. To clear these, the following heating process was used to advantage. The material was heated in water below boiling point causing it to melt and float on top upon cooling and allowing the foreign matter to settle at the bottom of the container. This process was repeated several times until the latex was sufficiently clean.

The washed latex was given various qualitative tests to determine what constituents were present. Results were as follows:

Xanthoproteic test for proteins	Negative
Molisch test for carbohydrates	Negative
Mitchell's colorimetric test for tannins	Negative
Solid waxes	Absent

Tests for solubility.—A pinch of the washed latex was treated with 0.6 cc of the solvent and the mixture observed after vigorous stirring. If it was not soluble, it was heated in a water-bath and another observation was made. The process was continued with a number of solvents and the following observations, arranged in the order of decreasing power of the solvents, were obtained:

In the cold, the latex was:

1. Soluble in chloroform, benzene, and ether.
2. Largely soluble in carbon tetrachloride and carbon disulfide.
3. Partly soluble in kerosene, petroleum ether, and acetone.
4. Slightly soluble in ethyl alcohol and absolute alcohol.

The mixtures were turbid at the beginning. However, the solubility increased and the solution became less turbid by heating, with the exception of the ether solution which became more turbid when heated.

Analysis of the latex.—Preliminary experiments were conducted to determine the best method for separating the different constituents of the nanka latex. The method outlined in the following diagram was found most convenient:

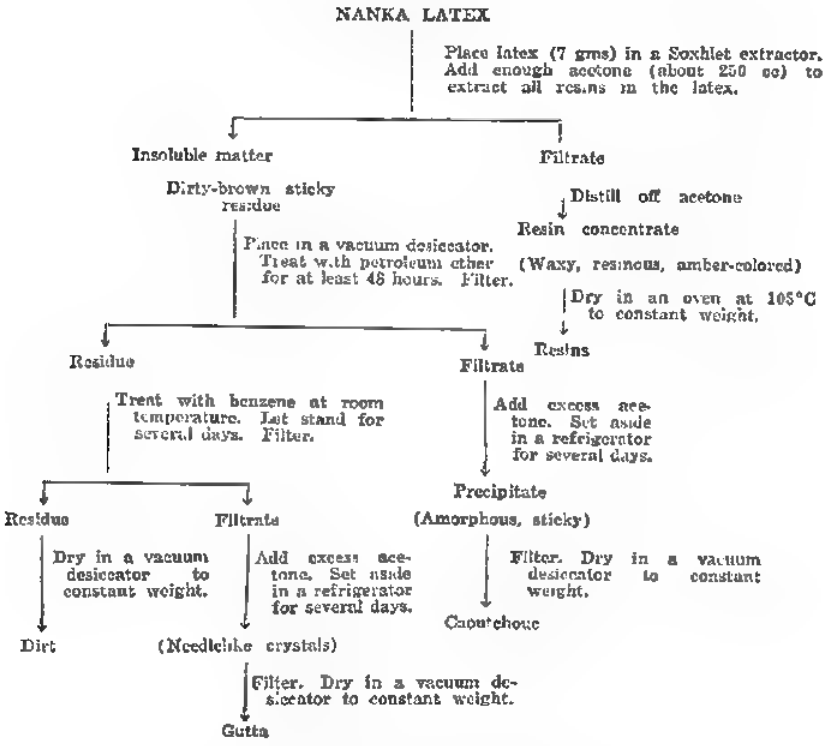

FIG. 1. Analysis of nanka latex.

Two samples, which were duplicates taken from four different fruits obtained from the same tree, were analyzed according to this method.

RESULTS

Our findings, showing the constituents and their percentages, are listed in Table 1.

TABLE 1.—*Composition of nanka latex.*

Constituent	Sample 1	Sample 2	Average
	Per cent	*Per cent*	*Per cent*
RESINS:	72.09	71.45	71.77
Albanes	8.45	8.58	8.52
Fluavitles	63.63	62.87	63 25
INSOLUBLE MATTER:	5.10	4.98	5.04
Caoutchouc	4.22	4 23	4 23
Gutta	0.23	0.18	0.23
DIRT:	0.60	0.57	0.58
Organic	0.52	0.49	0.50
Inorganic	0.08	0.08	0 08
MOISTURE (by dif.):	22.82	23.57	23.19
Total	100.00	100.00	100.00

Latex constituents.—The result of the analysis shows that the acetone-soluble constituent consists mainly of resins. These are composed of white resins (albanes) and yellow resins (fluavilles). The insoluble portion is composed of an elastic white precipitate (caoutchouc), which gradually turned dark on standing, and light-orange needlelike crystals (gutta). The residue constitutes the organic and inorganic dirt.

DISCUSSION

Extraction of resins.—Concerning the method of isolating the different constituents of the latex, especially the resins, Dannerth [2] states: "The extraction of rubber and related gums with boiling acetone is carried out principally for the purpose of determining the percentage of resins in the material."

Accordingly, boiling acetone was used as follows: Seven grams of latex accurately weighed in a folded filter paper was placed in a Soxhlet siphon cup and extracted with acetone for about three weeks. When extraction was complete, the acetone filtrate (lightly-yellow liquid) was distilled off and after all the acetone was removed the resin concentrate which appeared amber-colored, slightly transparent and resinous in texture, was dried in an oven at 105°C to constant weight. This represented the resins in the latex. On standing, this resinous residue became somewhat brittle.

Separation of the resins.—A portion of the resinuous residue was dissolved in hot ethyl alcohol and the yellow solution allowed to stand for at least four hours. The result was a white precipitate. This was filtered off, washed several times with cold ethyl alcohol until the washings were no longer colored, and dried in a desiccator to constant weight. The filtrate was concentrated on a steam bath and placed in an oven at 105°C to remove the last traces of alcohol. From this was obtained a yellow resinous transparent residue. The white precipitate consisted of the "albanes," while the yellow residue from the filtrate contained the "fluavilles." [3]

Separation of the insolubles.—The insoluble resinfree material in the Soxhlet thimble consisting of a dirty-brown sticky residue was treated with petroleum ether, placed in a refrigerator, and kept constantly agitated for several days. When an excess of acetone was added to this petroleum-ether solution, an

[2] Jour. Ind. Eng. Chem. 9 (1917) 630.
[3] India Rubber Journ. 64 (1922) 129.

amorphous white precipitate (caoutchouc),[4] which gradually turned dark after filtration through a weighed filter paper, was obtained. This was placed in a vacuum desiccator and dried to constant weight.

The material which did not dissolve in petroleum ether was treated with benzene at room temperature until the insoluble matter appeared dissolved. Excess acetone was then added to the benzene solution and placed in a refrigerator for several days. Light-orange colored needlelike crystals (gutta) were formed which were filtered through a weighed filter paper and dried in a vacuum desiccator to constant weight.

Dirt (organic and inorganic).—After separating the insolubles by means of petroleum ether and benzene, respectively, the residue[5] which did not dissolve in benzene was found to be organic and inorganic dirt. The weight obtained after ignition represented the "inorganic dirt." This weight subtracted from the original weight of the residue should give the amount of "organic dirt."

Moisture.—This was readily calculated by difference—that is, by substracting the combined weights of resin extract and insolubles from the original weight of the washed latex.

Solubility of resins.—The solubility of the resins obtained from the acetone-soluble extract was determined by the methods used for determining the solubility of latex. The following solvents are arranged in the order of their decreasing power to dissolve the resins.

In the cold, resin was:

1. Soluble in chloroform, benzene, and ether.
2. Largely soluble in carbon tetrachloride, carbon disulfide, acetone, and petroleum ether.
3. Partly soluble in kerosene.
4. Slightly soluble in ethyl alcohol and absolute alcohol.

The above mixtures were cloudy with the exception of chloroform and benzene. Upon heating, the cloudy mixtures became clear indicating complete solubility.

Resin constants.—The different resin constants were as follows:

(*a*) Saponification number	46.18
(*b*) Acid number	5.64
(*c*) Ester number	40.54
(*d*) Melting point	55.5°C

[4] Ind. Eng. Chem. 43 (1951) 402.
[5] Scott, W. Stand. Methods of Chem. Anal. 5th ed. 2 (1946) 1994.

These constants were determined according to the following procedures:

(*a*) *Saponification number.*—Approximately one gram of the resin was saponified with 50 cc of absolute alcohol and 25 cc of 0.5N alcoholic KOH. The solution was allowed to cool and the excess alkali titrated with 0.5N H_2SO_4 using phenolphthalein as indicator.

(*b*) *Acid number.*—The acid number was ascertained by treating approximately one gram of the resin with 50 cc of a neutral mixture of equal volumes of benzene and absolute alcohol. The solution was titrated with 0.5N alcoholic KOH in the presence of phenolphthalein.

(*c*) *Ester number.*—Ester number is the difference between the saponification and acid numbers.

(*d*) *Melting point.*—The mercury method of Durran as modified by Rangaswami and Sen [6] is as follows:

> . . . about 0.2 gram of the resin is weighed out into a Sillax porcelain crucible of 4 cm diameter and 17 cc capacity and gently heated on a wire gauze over a micro-burner until the resin begins to melt. In most cases the burner can be withdarwn at this stage as the heat will be enough to melt the whole resin gradually; otherwise, the heating should be stopped as soon as the whole resin melts in order to avoid overheating.
>
> The crucible is then allowed to cool, about 25 gms of mercury is poured into it and thermometer is supported with its bulb dipping in the mercury. The crucible is gently heated over a low flame protected from draughts until the resin first makes its appearance on the surface of the mercury, when the temperature is read without delay.

SUMMARY

The local jackfruit or *nanka* exudes an abundant white latex. Qualitative tests made on this latex showed that it contains neither proteins, carbohydrates, tannins, nor solid waxes.

In the cold, nanka latex was soluble in chloroform, benzene, and ether; largely soluble in carbon tetrachloride and carbon disulfide; partly soluble in kerosene, petroleum ether, and acetone; and slightly soluble in ethyl alcohol and absolute alcohol.

When dissolved in acetone, the material yielded 71.77 per cent resins consisting of albanes (white) and fluavilles (yellow). The insoluble matter, which made up 5.04 per cent, was dissolved

[6] A Handbook of Shellac Analysis (1942) 91.

in petroleum ether and benzene, yielding caoutchouc (an amorphous, elastic, white precipitate), and gutta (light orange needlelike crystals), respectively. The fibrous matter which was insoluble in benzene is organic and inorganic dirt. Moisture constitutes the remaining 23.19 per cent.

In the cold, the resins were soluble in chloroform, benzene, and ether; largely soluble in carbon tetrachloride, carbon disulfide, acetone, and petroleum ether; partly soluble in kerosene; and slightly soluble in ethyl alcohol and absolute alcohol.

The resin constants, which were also determined, were as follows: Saponification number, 46.18; acid number, 5.64; ester number, 40.54; and melting point, 55.5°C.

ILLUSTRATION

PLATE 1

Nanka tree (*Artocarpus integra* Merr.)

PLATE 1.

A STUDY OF PHILIPPINE BOTHROGONIA (HOMOPTERA: CICADELLIDÆ) WITH REFERENCE TO THE FEMALE SEVENTH STERNA AND INTERNAL MALE GENITALIA

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THREE PLATES

Bothrogonia China of the subfamily Tettigellinæ, tribe Tettigellini, has long been known in the Philippines as *Tettigoniella* Jacobi (1903). Merino(4) used the name *Cicadella* Latreille (1817) in which he also included all species of the genus *Tettigella* China et Fennch, 1946.

This group of insects from the Philippines has not long been studied in detail. The *Bothrogonia* species in the collections of the Philippine Natural History Museum and the leafhopper collections of Merino, which both perished during World War II were all mixed up and not properly separated to distinct species. The same is true with the leafhoppers in the Baker Collections in the United States National Museum. These leafhoppers are very similar in appearance so that a critical study of the genitalia is essential to separating them to species.

The present study was based on the leafhopper collection of the Bureau of Plant Industry, Manila, designated as BPI Collection and of the College of Agriculture, University of the Philippines designated as CA (UP) Collection.

I wish to acknowledge gratefully the encouragement given me by Dr. Gonzalo Merino, retired entomologist and former director of the Bureau of Plant Industry, Manila, and Dr. David Young, Jr., entomologist in the United States National Museum. I appreciate very much the guidance that Young gave me on the dissection of male internal genitalia of leafhoppers. Thanks are also due to Dr. S. M. Cendaña for making the leafhopper collection of the Department of Entomology, College of Agriculture, University of the Philippines, available for my study.

Genus BOTHROGONIA China, 1938

Bothrogonia China, Ann. Mag. Nat. Hist. Ser. II 2 (1938) 183; Evans, Trans. Ent. Soc. Lond. (6) 98 (1947) 160; Ishihara, Sci. Rep. Matsuyama Agr. Coll. 14 (1954) 12.

Bothrogonia MELICHAR, Ann. Mus. Nat. Hung. 23 (1926) 431 (Invalid name because of the type not designated).

Cicadella Latreille, CURVIER, Regne Animal 3 (1817) 406; KIRKALDY, Can. Ent. 39 (1907) 349; VAN DUZEE, Check List Hem. (1916) 66; MERINO, Philip. Jour. Sci. 61 (1936) 330–331.

Tettigonia REAUMUR, Memoirs 5 (1740) 150 (pre-Linnean); GEOFFROY, Hist. Abreg des Ins. 1 (1762) 429 (nom. praeocc.); SIGNORET, Ann. Soc. Ent. Fr. (1853) 323; VAN DUZEE, Trans. Am. Ent. Soc. 21 (1894) 271.

Cicada FABRICIUS, Syst. Ent. (1775) 682 (name cited in error); LINNÆUS, Syst. Nat. 1 (1758) 438 (*Cicada viridis*).

Tettigoniella JACOBI, Zool. Jahrb. 19 (1903) 778, nom. nov.; DISTANT, Faun. Brit. Ind. Rhynch. 4 (1908) 201.

Megalotettigella ISHIHARA, Sci. Rept. Matsuyama Agr. Coll. 11 (1953) 3, 16 (syn. nov.)

Genotype: *Cicada ferruginea* FABRICIUS, 1794 (by designation).

Large, elongate and rather slender. Head wider than pronotum, roundly or subangularly produced; face moderately globose and elongate without either carina or foveola, lateral areas transversely striate. Pronotum longer margin truncate. Scutellum small, an almost arcuate and transverse impression before apical area. Tegmina longer than abdomen, apical areas five. Posterior tibiæ longly spinulose.

Ishihara(2) erected the genus *Megalotettigela*, with *Cicada ferruginea* Fabr. as the genotype, not knowing that China (1938) had previously erected the genus *Bothrogonia* for this group of leafhoppers.

According to Ishihara,(3) Melichar's genus *Bothrogonia* was invalidated because he failed to designate the type of the genus in 1926.

Key to Philippine species of Bothrogonia

FEMALE

(Based on the seventh sterna)

1. Seventh sternum solid or without arm, only with a V-like incision at middle of distal margin and with an inverted Y-like carina on disc. *impudica* (Signoret)
   Seventh sternum with 2 arms or lobes 2
2. Arms of seventh sternum with rounded apical margins 3
   Arms of seventh sternum with pointed apical margin 4
3. Distal margin of each arm with a small pointed portion towards inner side ..... *ferruginea* (Fabricius)
   Distal margin of each arm without a small pointed side toward inner side but, with almost a semicircular notch at the center of the U-margin ..... *piceata* sp. nov.
4. Margin of arms acutely pointed ..... *minica* sp. nov.
   Margin of arms very acutely pointed at tip 5

5. Pointed arms short ..... *longa* (Walker)
   Pointed arms long and wide, bent toward inside a shallow V-like cut at middle of U-margin ..... *Philippina* (Walker)
   Arms long and narrow, with shallow V-like cut at middle of U-margin ..... *argyrops* (Signoret)
   Arms long and narrow without cut at middle of U-margin ..... sp.

MALE

(Based on structure of internal genitalia)

1. Ædeagus with a single process provided with connecting arm 2
   Ædeagus with a pair of processes arising from base, without connecting arm 3
2. Process pointed at tip with 2 sawlike blades, one on each side. *impudica* (Signoret)
   Process pointed and finely serrated near tip without sawlike blades. *longa* (Walker)
3. Processes triangular at lateral view 4
   Processes not triangularlike but long empty cowpea beanpod 5
4. Processes from distal half curved upward towards tip, with serrated blades on both dorsal and ventral margins ..... *philippina* (Walker)
   Processes from half to tip straight, with serrated blades only at dorsal margin ..... *ferruginea* (Fabricius)
5. Ædeagus with a prominent armlike branch, a third from base. *piceata* sp. nov.
   Ædeagus with less prominent armlike branch, a third from base. *mimica* sp. nov.
   Ædeagus with less prominent armlike branch, but processes curved ventrally near tip and with large spinelike branch at middle, tip somewhat shoelike ..... *argyrops* (Signoret)

1. BOTHROGONIA FERRUGINEA (Fabricius). **Plate 1, fig. 1; Plate 2, figs. 6, 7.**

Tettigoniella ferruginea FABRICIUS, Ent. Syst. 4 (1794) 32; (*Cicada*); Syst. Rhyng. (1803) 62; GERMAR, Mag. Ent. 4 (1821) 69 (Tettigonea); SIGNORET, Ann. Soc. Ent. Fr. (1853) 676, Plate 22, fig. 5; WALKER, List. Hom. Suppl. (1858) 218; ATKINSON, Jour. As. Soc. Bengal 54 (1885) 98; CHINA, Ann. Mag. Nat. Hist. ser. 11 2 (1938) 182 (*Bothrogonia*); MERINO, Philip. Jour. Sci. 61 (1936) 332 (*Cicadella*); ISHIHARA, T. Sci. Rept. Matsuyama Agr. Coll. 11 (1953) 16, Plate 14, figs. 4a, 4b, 4c, 4d; Plate 16, figs. 2g, 2h (*Megalotettigella*).

Tettigonia apicalis WALKER, List Hom. 3 (1851) 736.

Tettigonia confinis WALKER, List Hom. 3 (1851) 736.

Tettigonia addita WALKER, List Hom. 3 (1951) 737.

Tettigonia gemina WALKER, List Hom. 3 (1851) 737; MELICHAR, Hom. Fauna Ceylon (1903) 155.

Tettigonia obscura WALKER, List Hom. 3 (1851) 738.

Tettigonia duplex WALKER, List Hom. 3 (1851) 738.

Tettigonia reducta WALKER, List Hom. 3 (1851) 739.

Tettigonia immaculata WALKER, List Hom. 3 (1851) 740.

Length 12.5 to 13.5 millimeters.

Rufo-testaceus, slender; apex of tegmina light black.

Female seventh sternum distinctive, with two arms, apical margins rounded with a small pointed portion towards inner side.

Male ædeagus distinctive, a pair of processes arising from base, without a connecting arm; process triangular at lateral view, apical half straight, serrated blades only at dorsal side.

BPI Collection.—LUZON: Mountain Province (Baguio); Bataan Province (Lamao); Rizal Province (Balara, Montalban, Antipolo); Laguna Province (Mt. Maquiling, San Pablo); Batangas Province (Cuenca); Albay Province (Guinobatan); Sorsogon Province (Poet). NEGROS: Negros Oriental Province (Mt. Canlaon).

CA (UP) Collection.—LUZON: Laguna Province (Mt. Maquiling, Los Baños, College); Quezon Province (Baler, Lucena, Tagkawayan); Albay Province (Guinobatan). NEGROS: Negros Oriental Province (Valencia). MINDANAO: Cotabato Province (Kabaoan).

This species is a pest of coconut (*Cocos nucifera*), sugar cane (*Saccharum oficinarum*), mango (*Mangifera indica*), coffee (*Coffea* sp.), camias (*Averrhoa bilimbi*), and cucurbits in the Philippines. This is a variable species; Distant(1) enumerated six varieties from India.

2. BOTHROGONIA IMPUDICA (Signoret). **Plate 1, fig. 2, Plate 2, figs. 8-10.**

Tettigonia impudica SIGNORET, Ann. Soc. Ent. III 1 (1853) 132, 677 (Manila); STÅL, Hem. Ins. Philippinarum 2 (1870) 733; TASCHENBERG, Zertz. Natur. 57 (1884) 430 (Siam).

Tettigoniella impudica SIGNORET, Baker, Philip. Jour. Sci. § D 4 (1909) 553; Philip. Jour. Sci. 5 (1910) 50 (Palawan).

Cicadella impudica SIGNORET, Merino, Philip. Jour. Sci. 61 (1936) 332.

Length, 12 to 13 millimeters.

Slender, linear, reddish-brown. Vertex pale reddish-brown; lateral striation of face brown; tegmina dark reddish brown.

Vertex with sulcated areas between disc and lateral margins; pronotum longer than vertex.

Female seventh sternum, distinctive, solid or without arm, a V-like incision at middle of outer margin, and with an inverted Y-like carina on disc.

Male ædeagus distinctive, T-like (at side view), a single process, held together by a connecting arm. Process pointed

at tip, with 2 sawlike blades, one on each side. Style curved and slightly pointed at tip.

BPI Collection.—LUZON: Laguna Province (Mt. Maquiling); Batangas Province (Cuenca).

CA (UP) Collection.—LUZON: Laguna Province (Mt. Maquiling); Quezon Province (Atimonan). LEYTE: Baybay. NEGROS: Negros Oriental Province (Valencia).

3. BOTHROGONIA LONGA (Walker). **Plate 1, fig. 3; Plate 2, figs. 1-3.**

Tettigonia longa WALKER, List Hom. 11 (1851) 740.
Cicadella longa WALKER, Merino, Philip. Jour. Sci. 61 (1936) 331.

Length, 12.5 to 13.5 millimeters.

Ferrugineus, pale towny beneath; tegmina pale near apical margin; hind wings coppery.

Vertex roundly produced, sulcated areas between oceli and lateral margins and another on disc near base; pronotum, a little longer than vertex; scutellum triangular almost as long as pronotum.

Female seventh sternum distinctive, with two arms, short, margins very acutely pointed at tips.

Male ædeagus distinctive, clublike cut open at enlarged end, connected to process by an arm; process curved inward near apex, without sawlike blades but somewhat finely serrated very near pointed tip.

BPI Collection.—MINDANAO: Cotabato Province (Kidapawan, Parang).

CA (UP) Collection.—MINDANAO: Davao Province (Davao City); Surigao Province (Mt. Apo); Bukidnon Province (Malaybalay).

Signoret (1853) placed this species as a synonym of *ferruginea.* In 1936, Merino considered this as a distinct species basing from the determination of China in the Baker Collection, U.S. National Museum. By mistake, the figures for *longa* given by Merino are for *ferruginea.*

4. BOTHROGONIA ARGYROPS (Signoret). **Plate 1, fig. 4; Plate 2, figs. 4, 5.**

Tettigonia argyrops SIGNORET, Ann. Soc. Ent. Fr. (1853) 678.

Length, 12 to 13 millimeters.

Reddish dark brown; oval area at center of frons; areas near lateral margins, side of thorax and abdomen, yellowish brown, fore and middle tibiæ and tarsus reddish dark brown.

Vertex shorter than *ferruginea*, roundly produced anteriorly, a large depression on disc and two at the sides between ocelli and lateral margins; pronotum, with five impressions.

Female seventh sternum distinctive, with 2 arms, long and narrow, with a shallow V-like cut at middle of U-margin, slightly curved inward near tip.

Male ædeagus distinctive, with less prominent armlike branch; processes paired arising near base, a little longer than ædeagus, curved ventrally near tip and having a large spinelike branch at middle, tip somewhat shoelike.

CA (UP) Collection.—LEYTE: Mt. Mangasagan, Balinsasayao, Maasin, Alangalang.

This species is similar to *longa* only it is darker and slightly smaller.

5. BOTHROGONIA sp. Plate 1, fig. 5.

Length, 12 to 13 millimeters.

Similar to or approaching *argyrops* Signoret but smaller and paler in color.

Female seventh sternum like that of *argyrops* but without the shallow V-like structure at the center of U-margin.

The specimens on hand are 4 females and without any male.

BPI Collection.—LUZON: Mountain Province (Banawe); Abra Province (Basiwag).

6. BOTHROGONIA PHILIPPINA (Walker). Plate 1, fig. 6; Plate 3, figs. 1-3.

Cicadella philipina WALKER, List Hom. Ins. 3 (1851) 740; MERINO, Philip. Jour. Sci. 61 (1936) 33.

Tettigonia philippina SIGNORET, Ann. Soc. Ent. III 1 (1853) 122, 674, Plate 22, fig. 31; STÅL, Ofv. Akad. Forh. (1870) 27, 733.

Length, 13.5 to 15 millimeters.

Black; three marginal spots of vertex, central spots of ferns, genæ, loræ, lateral spots of pronotum extending to sides, anterior spot of scutellum, lateral margins of thorax and abdomen yellow; a wide median stripe to apex of tegmen, posterior margins of abdominal sterna reddish brown; legs dark brown.

Vertex, a large depression on disc near the posterior margin.

Female seventh sternum distinctive, with two long and wide arms, and slightly bent inward near pointed tip, a V-like cut at middle of U-margin.

Male ædeagus, distinctive, curved upward, with two triangular processes (at side view) arising from base; distal half of

process curved upward towards tip with serrated blade on both dorsal and ventral margins.

BPI Collection.—MINDANAO: Cotabato Province (Parang).

7. **BOTHROGONIA PICEATA** sp. nov. Plate 1, fig. 7; Plate 3, figs. 4-6.

Length 12.5 to 13 millimeters.

Ashy black; vertex, frons, anterior third of pronotum, light to dark brown; genæ, plura, pectus, ventral and sides of abdomen yellow; dorsal side of abdomen black; spots an upper corners of abdominal sterna, fore and middle tibiæ and tarsi blackish-brown; posterior two-thirds of pronotum, scutellum, tegmina black; apical area of tegmina reddish black brown.

Head wider than pronotum; vertex with three impressions, one on disc near base, two between the oceli and eyes; pronotum with a transverse impression near middle.

Female seventh sterna, distinctive, with arms rounded at apical margins, without a small pointed area towards inner side, with a V-cut notch at the center of U-margin.

Male ædeagus, distinctive, with a prominent armlike branch a third from base; a pair of processes arising from base; not triangular, long, like an empty cowpea pod.

Type: 4 females, 3 males; Cuenca, Batangas, Luzon (F. Candelaria, 1954, BPI Coll.)

BPI Collection.—LUZON: Cavite Province (Tagaytay City); Batangas Province (Cuenca, Lipa City, Mt. Makulot).

8. **BOTHROGONIA MIMICA** sp. nov. Plate 1, fig. 8, Plate 3, figs. 7-10.

Length, 13 to 14.5 millimeters.

Black, similar to *piceata* abdomen yelowish brown; anterior half of each abdominal sternum brown.

Female seventh sternum distinctive, with 2 arms, apical margin acutely pointed.

Male ædeagus, with a less prominent armlike branch a third from base; a pair of processes arising from base not triangular at side view; style curved at tips with straight outer margin.

This species is very similar to *piceata* in size, color and other respects. One can be distinguished from the other by examining the female seventh sternum, the color of the abdomen, and after dissecting the male genitalia.

Type: 3 females, 2 males; Mt. Maquiling, Laguna, Luzon (E. M. Dagang, 1954, BPI Coll.).

BPI Collection.—LUZON: Laguna Province (Mt. Maquiling, College); Quezon Province (Atimonan; Tagkawayan); MINDANAO: Bukidnon Province (Malaybalay).

9. **BOTHROGONIA NORMA** (Signoret).

Tettigonia norma SIGNORET, Ann. Soc. Ent. III 1 (1853) 671, Plate 21, fig. 15 (Manila).

Similar to *ferruginea* but smaller and with a transverse fascia on vertex and perpendicular fascia on face black as illustrated by Signoret (1853) Plate 21, fig. 15.

I have not seen this species in the collections so that no detailed study of this was made.

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ILLUSTRATIONS

PLATE 1

[Female seventh sternum, ventral view.]

FIG. 1. *Bothrogonia ferruginea* (Fabricius).
2. *B. impudica* (Signoret).
3. *B. longa* (Walker).
4. *B. argyrops* (Signoret).
5. *B.* sp.
6. *B. philippina* Walker.
7. *B. piceata* sp. nov.
8. *B. mimica* sp. nov.

PLATE 2

[Male internal genitalia of *B. longa* Walker.]

FIG. 1. Lateral view of ædeagus.
2. Ventral view of ædeagus.
3. Dorsal view of whole internal genitalia.

[Male internal genitalia of *B. argyrops* (Signoret).]

4. Lateral view of ædeagus.
5. Dorsal view of whole internal genitalia.

[Male internal genitalia of *B. ferruginea* (Fabricius).]

6. Lateral view of ædeagus.
7. Dorsal view of whole internal genitalia.

[Male internal genitalia of *B. impudica* (Signoret).]

8. Lateral view of ædeagus.
9. Ventral view of ædeagus.
10. Dorsal view of whole internal genitalia.

PLATE 3

[Male internal genitalia of *B. philippina* (Walker).]

FIG. 1. Lateral view of ædeagus.
2. Ventral view of ædeagus.
3. Dorsal view of whole internal genitalia.

[Male internal genitalia of *B. piceata* sp. nov.]

4. Lateral view of ædeagus.
5. Ventral view of ædeagus.
6. Dorsal view of whole internal genitalia.

[Male internal genitalia of *B. mimica* sp. nov.]

7. Lateral view of ædeagus.
8. Ventral view of ædeagus.
10. Dorsal view of whole internal genitalia.

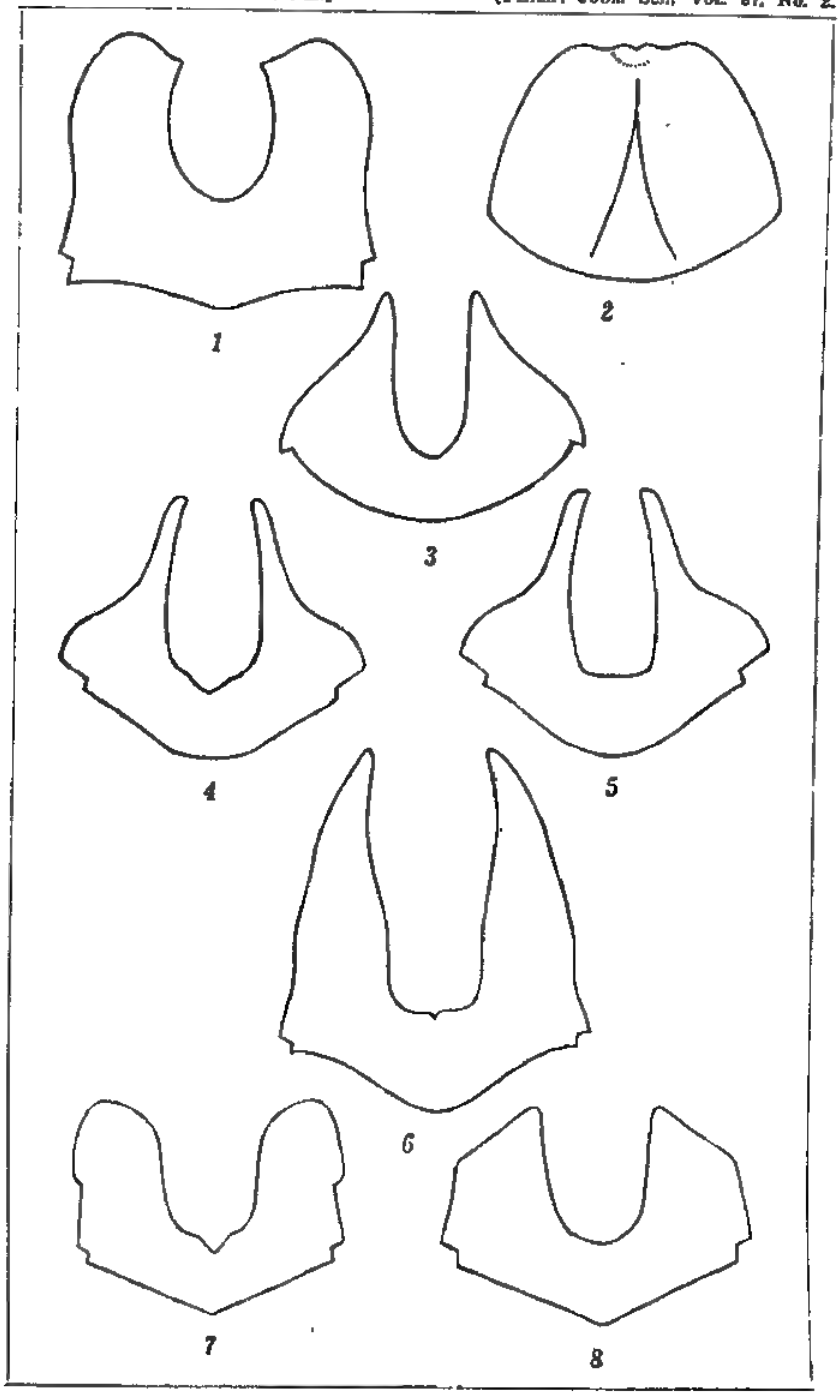

PLATE 1.

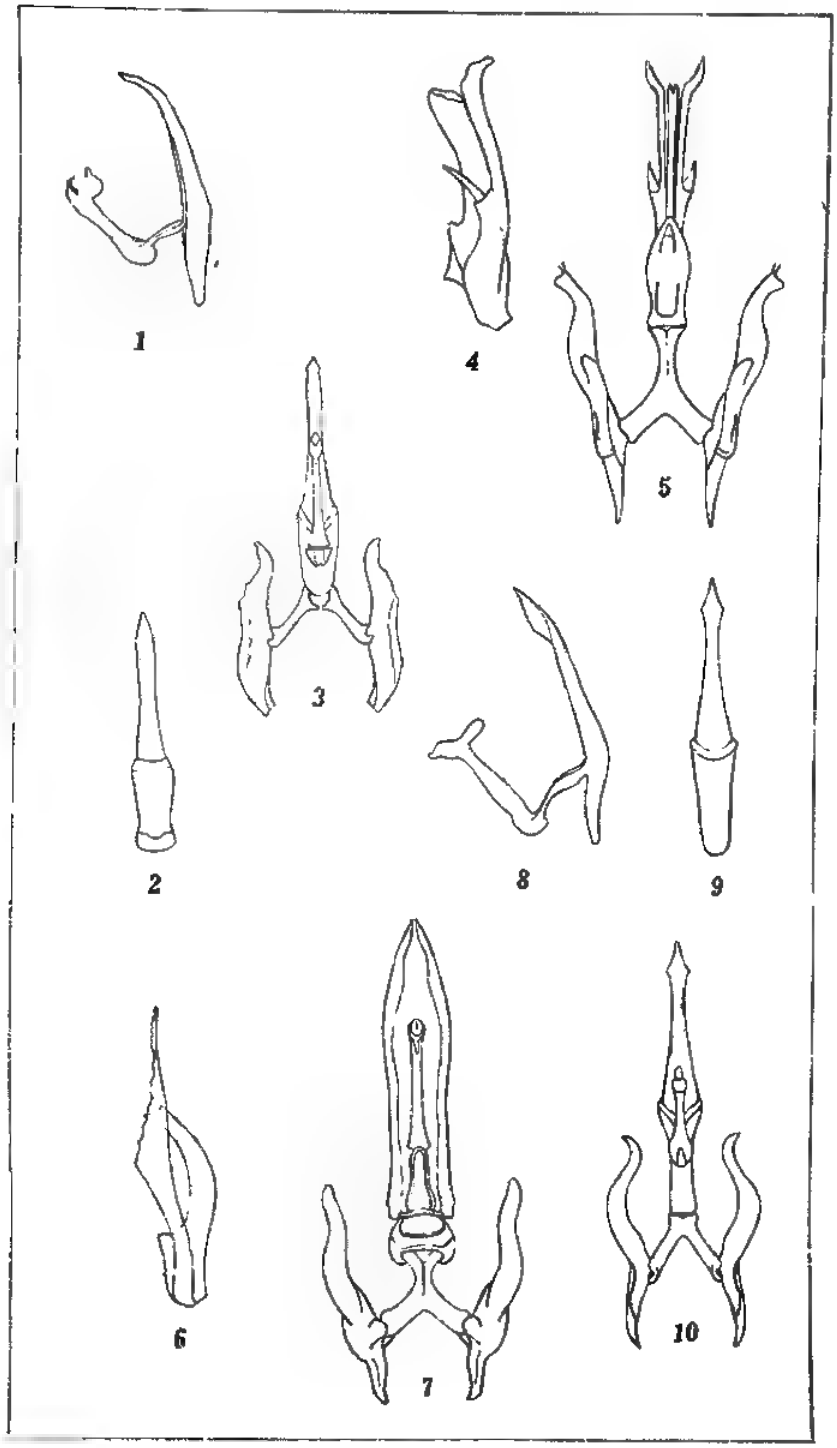

PLATE 2.

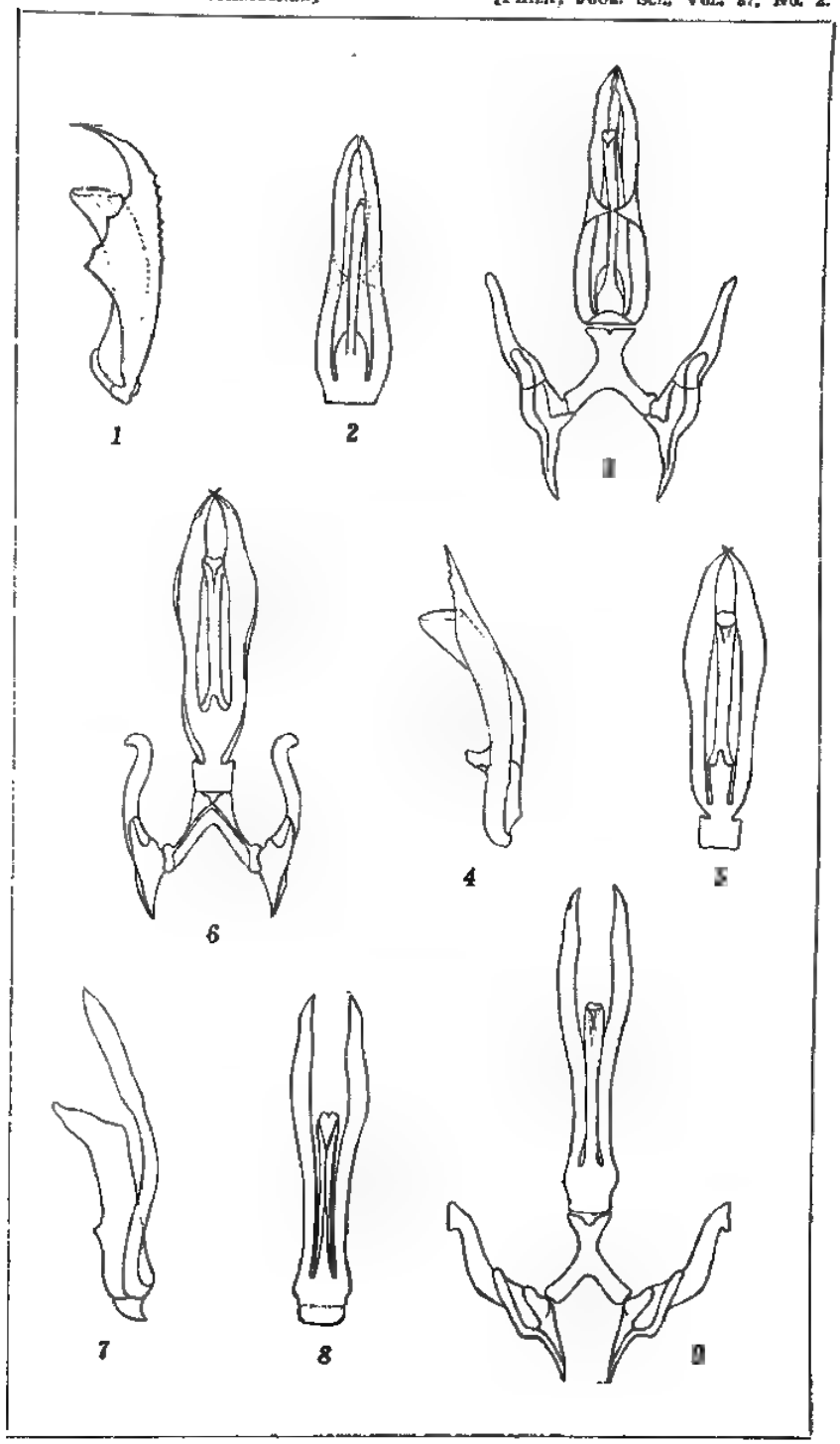

PLATE 3.

SALT CONSUMPTION BY NATIVES OF THE TERRITORY OF PAPUA AND NEW GUINEA

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ONE TEXT FIGURE

INTRODUCTION

The optimum daily salt intake has yet to be determined, despite the fact that the practice of adding salt to food is almost universal. There are still some societies extant today which, having no access to commercial salt (NaCl), have evolved their own methods for producing "salt" substitutes. That these methods are laborious and time consuming is indicative of a need felt for some external stimulation to the local food. Kaunitz(9) has provocatively suggested a correlation between salt intake and emotional stimulation.

Moszkowski(14) noticed that salt, as we know it, was totally unknown to the natives of New Guinea. In fact, they repulsed with obvious distastes any salted foods given them. However, they prepared their own "salt" by several methods from burning plants. Samples from 12 such salts made in the Territory of Papua and New Guinea and one from Netherlands New Guinea were forwarded to Canberra for analysis.

METHODS

Thirteen native-prepared salt samples from various districts in New Guinea were analyzed for sodium, potassium, magnesium, chloride, sulphate and iodine. The Na^+ and K^+ were estimated using an EEL flame photometer, Mg^{++} by a method of Haury,(6) Cl volumetrically [Winton, (17)], SO_4 by the usual gravimetric procedure, and iodine by a modified method of Andrew and Mandeno.(2) The analysis of some samples is incomplete due to insufficient material.

RESULTS

The results are set out in Table 1. All figures are expressed on a dry-weight basis.

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TABLE 1.—*Chemical composition of New Guinea native salt samples.*

Village	Sub-district	District	Na	K	Mg
			mg/100 gm	*mg/100 gm*	*mg/100 gm*
1. Guava	Kieta	Bougainville Island	290	28,700	None detected
2. Onovi	do	do	250	26,850	do
3.	Mumeng	Morobe	112	45,500	
4.	Menyamya	do	110	44,300	None detected
5. Droinggam	Telefomin	Sepik	160	27,400	
6. Amaiva	Kainantu	Eastern Highlands	60	46,150	None detected
7.	Chimbu	do	90	49,600	375
8. Deri	do	do	30,000	6,000	
9. Mouth of Ramu R.	Bogia	Madang	7,675	630	144
10.	do	do	9,880	4,820	104
11. Gwiarak	Saidor	do	20,300	930	156
12. But	Wewak	Sepik	32,800	320	540
13. Wissel Lakes	do	Netherlands New Guinea	29,500	218	

Village	Sub-district	District	Cl'	SO_4''	I_2
			mg/100 gm	*mg/100 gm*	*p. p. m.*
1. Guava	Kieta	Bougainville Island	9.5	6.4	None detected
2. Onovi	do	do	9.4		do
3.	Mumeng	Morobe			
4.	Menyamya	do	29.0	16.0	None detected
5. Droinggam	Telefomin	Sepik	20.0		4.3
6. Amaiva	Kainantu	Eastern Highlands	26.8	8.8	None detected
7.	Chimbu	do	41.4		do
8. Deri	do	do	55.5	2.0	do
9. Mouth of Ramu R.	Bogia	Madang	14.0	2.2	do
10.	do	do	23.5		do
11. Gwiarak	Saidor	do	30.1	5.3	do
12. But	Wewak	Sepik	64.7	4.8	do
13. Wissel Lakes	do	Netherlands New Guinea			2.2

DISCUSSION

Hipsley(8) has given a short account of some methods of salt production and of the salt eating customs of the natives of New Guinea.

A large amount of additional information has become available in the course of this investigation. As it is of interest anthropologically, as well as nutritionally, a detailed account will be given. (Fig. 1)

Bougainville Island.—In the villages of Onovi and Guava the salt is prepared by burning the wood and the leaves of several plants. One of the plants used has a fleshy stem and may be eaten raw but its species is unknown. The ashes are wrapped in leaves and hung over the fireplace in the natives' huts to prevent deliquescence. When it is needed some of the ashes are placed in a container with water. After the salt has dissolved and the sediment settled out, the salty water is decanted and used in cooking. The two samples analysed are very similar in composition. It would appear likely that carbonate forms a high proportion of the basic radicle.

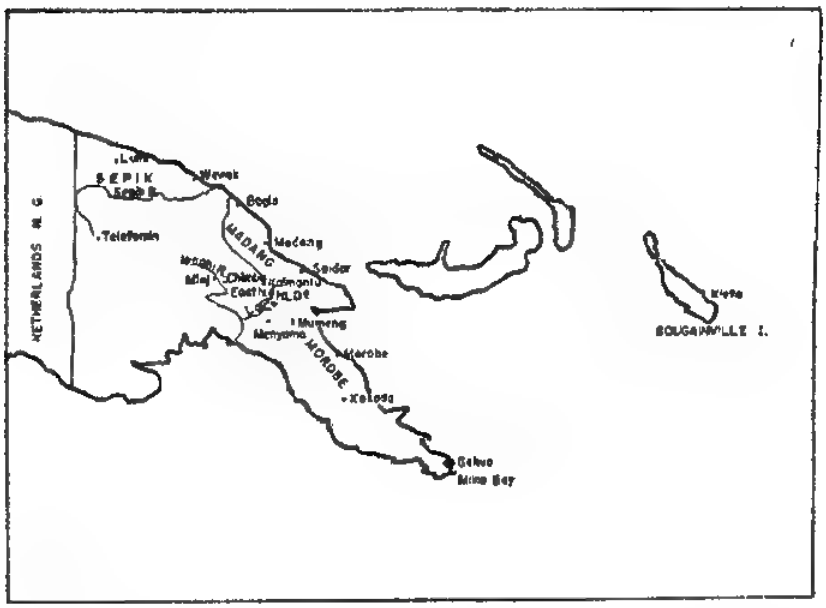

FIG. 1. Map indicating the territory of the various districts mentioned.

Morobe district.—The sample from Mumeng was probably prepared from plants of the *Saccharum* species. The sample from the Menyamya area was stated to be of plant ash type. Both samples have a similar sodium and potassium content.

Sepik district.—The only information available about the sample from Droringgam is that it was made from plant ashes. Nowadays, however, in this area salt is supplied from the Government stores. The iodine content of the sample analysed is

of interest. No cases of goiter or cretinism have been reported in the locality.

At But the villagers boil sea water in a 44-gallon drum until salt crystals are seen. In order to prevent the crystals darkening a bucket of fresh water is added and then boiled dry. There are no salt springs around Wewak. Before the war sago palms were burnt to extract salt, but this method has been discontinued.

A salt sample from Kup in the Minj area of the Sepik district consisted essentially of sodium chloride with a slight admixture of potassium. Here the salt is made by soaking grass in a small spring, drying, then burning the grass and extracting the resulting ash with water which is then evaporated. Obviously the spring must be saline.

The villagers of Eritei and Yebil, Lumi area, Sepik district, cook their food in water from brackish springs giving the food a slightly salty flavor. They do not make their own salt and attempts at extracting salt by evaporation of the water from the springs have been unsuccessful.

Eastern Highlands.—There is an interesting legend telling of the origin of the salt works at Deri, on the Waghi River. Long before the white man came two natives from the eastern bank of the Waghi River came across to Deri, on the western bank for a "sing-sing." When they were about to cross the bridge on their return home in the early hours of the morning one of them looked over his shoulder and saw two native women who had been with them earlier in the night. But when they turned and walked back they were unable to find the two women even though they searched thoroughly. By this time it was morning and the sun was strong and they too felt strong. Then they noticed a small seepage—the present salt works. They celebrated by killing two pigs and feasting. During the night the voices of dead ancestors told the natives how to process the liquid to give salt. The method used today is the same.

Water from the spring seeps into a mud and stone pool, taking about 24 hours to fill the pool. It is then transferred to nearby specially dug stone pits. Grass, (probably kunai grass) called kulbibe by the natives, is soaked in the liquid and then dried. This may take up to four weeks. The dried grass is carried away to the natives' homes where it is burnt,

sometimes taking another week. The ashes are gathered and mixed with water and cooked in scooped out sections of stone. The natives then add water to the fired grass which is contained in filters made of banana leaves and the size of a cup. The seepage from the bottom of the cup is practically pure native salt. Water may be evaporated off again so that the ashes can be kept. The Deri and Onimogma people are regarded as owners of the salt works. A large number of temporary native huts have been built near the spring and everyday the water at the spring is rationed out. Natives from all over the district generally trade food for the salt.

From the chemical composition of the sample analyzed it is obvious that the seepage at Deri must be a saline spring. A. M. Maahs(13) has described in detail the salt making process of a village on the Waghi River. As the salt works at Deri are believed to be the only ones in the district it is probably Deri he described. Maahs noted that the salty water of the spring was sulphur tasting which after evaporation left a quite unpalatable sulphurous residue. A sample of salt from the Chimbu district sent to the Institute of Anatomy in 1951 for analysis contained 38 per cent sodium, 56 per cent chloride, and 2.41 per cent of potassium carbonate. It seems feasible that it may have come from Deri also as the other salts from the Eastern Highlands consist mainly of potassium. No iodine was detected in the sample, and the magnesium content was 200 mgm per cent.

Sample No. 7 from the Chimbu sub-district was prepared similarly to begin with. After the plants are ashed and dried the ashes are placed in baskets made of pandanus leaves under banana trees so that the rain water runs off the bananas, into the basket, seeps through the ashes, then escapes through a small hole in the bottom of the basket into a bark funnel directing it into lengths of bamboo. The ashes are stirred occasionally and removed after a sufficient amount of rain water has run through them. The rain water is boiled slowly for about 12 hours in large circular containers made of leaves, fibers, grass, and cane. A superstition held by the natives is that should the container leak during the evaporation the worker will die unless he kills a pig immediately.

In the whole of the Lamari area the salt is processed and eaten by the same methods. Certain leaves growing on small shrubs in the northern part of the area are gathered by the

village men and burnt. The ashes are mixed with water to a consistency detected by taste. The mixture is poured into a hollow vessel with small holes at one end. Water is poured through and collected in clay bowls then evaporated off over large fires. The salt is eaten with pig, taro, sweet potato, etc. A mouthful of food is eaten, then a portion of salt. Samples 6 and 7 are similar in their sodium and potassium content, but differ in magnesium content.

Madang district.—Gwiarak natives, who live south of the Saidor Government station, pour sea water on to a large fire which they build on the beach. After evaporation the salt and the ashes are carried back to their village, a day's walk inland. The coastal natives use sea water for cooking, and some inland natives even carry sea water to their villages.

Of the two other samples from this district, sent from Bogia, one was prepared as above, by burning driftwood, and the other was made by burning the stalks of a swamp palm similar to the sago palm. The natives regard this as a superior salt to that obtained from driftwood alone. This salt is traded with inland natives for clay pots.

Wissel Lakes.—The lakes are situated in Netherlands New Guinea at a height of 7,000 feet. There are three tribes in the district who either make the salt or trade it. The Moni tribe live around the spring and so having no need to carry the salt any distance frequently they just dip a branch of leaves in the spring and carry away the impregnated leaves. A second method is to impregnate with salt water a branch of a succulent vine and pack it into a small leaf-lined hole in the ground. After drying the vine on the fire it is again packed tightly into the hole. The leaves which line the hole are then drawn together and the packet removed and bound with rattan. The packet is very hard, long, and brown in color. The salt is consumed by breaking small pieces off or by licking it.

The sample analyzed was obtained from a native trader at Wissel Lakes and was believed to have been prepared from salt springs. This is confirmed by the analysis results.

Milne Bay area.—Before the advent of Europeans, natives near Gehua prepared their own salt by buring driftwood, but now they purchase their own salt. In this district the coastal people add sea water to their cooking-pots in the ration of 1:7 with fresh water. Inland, the natives boil

one or two leaves of a certain tree to give a salty flavor to their cooking.

Kokoda district.—Here the natives have ceased making their own salt. Previously they made one type from a vine, taking two months in the process, and another type from a tree.

The results tabulated indicate that salts made from plant ash alone are mainly potassium salts. This confirms the results of some previous analyses of native salts obtained from Netherlands New Guinea and mentioned by C.C.F.N. Le Roux(12) in a detailed account of salt preparation and consumption in that area. One of the salts, collected from the mountains in Netherlands New Guinea, was made by soaking grass leaves (*Imperata* sp.) in brine, then drying them. These two stages were repeated several times, then the leaves were ashed and the ash extracted with brine. The water was evaporated off leaving salt bricks. This salt had a NaCl content of 74 per cent. By comparison, a salt prepared in Africa from this same species, *Imperata,* contained 10.6 per cent Na_2O and 45.4 per cent of K_2O [Adriaens and Waegemans,(1)].

Porteres(16) has collated the chemical composition of a large number of salts made in Africa from plant ashes. Again most are mixtures of potassium salts and contain little or no sodium except for a few made from plants growing in saline soils which contain substantial amounts of NaCl.

Pales(15) noted that the area of endemic goiter in French West Africa was roughly coincident with that in which salts from plant ashes were used. However, Hipsley(7) saw many marked cases of goiter which tended to be concentrated in localized pockets of the population. Villagers in nearby valleys could be completely free of goiter. It has been suggested that in villages of the former type the soil may be deficient in iodine. As there is little trade from outside, the food grown and the water collected from this soil provides an inadequate amount of iodine to satisfy body requirements. There is a possibility that food containing goiterogenic substances may be responsible [Clements,(5)].

Only two of the samples analyzed contained iodine. It is of interest that one of these samples was from the Telefomin area where no cases of endemic goiter have been reported. However, as previously stated, the natives there now obtain

their salt from the Government stores. Goiter has not been reported either in the Lumi area of the Sepik district.

The question arises of the physiological value of these potassium salt substitutes.

Von Bunge(4) postulated that people living on carnivorous diets did not need to add salt to their food, whereas those on vegetarian diets needed extra salt to keep constant the saline composition of the body by counteracting the superabundance of potassium salt. Lapicque,(11) a French physiologist, disputed Bunge's theory. He considered that NaCl was merely necessary as a condiment, as evidence by the fact that certain primitive tribes used potassium salts extracted from plants instead of NaCl. Porteres,(16) however suggests that it may be the individual's requirement for chloride which is important, the cation being irrelevant.

This theory does not take into account the fact that a large number of the salts analyzed are not rich in chloride and probably consist mainly of carbonate. Kaunitz(10) has recently shown that the action of chloride is different in the presence of sodium and potassium. The feeding of equimolecular amounts of NaCl or $NaHCO_3$ to rats produced kidneys of different sizes, the former being the larger. The feeding of KCl resulted in small kidneys. Sodium and potassium are therefore antagonistic in their relation to chloride.

The diet of the natives in New Guinea is mainly vegetarian [Barrau,(3)]. Therefore the addition of salt found to consist mainly of potassium compounds to what must be a diet already containing ample potassium probably has very little value physiologically.

SUMMARY

Thirteen samples of salt prepared by natives in New Guinea have been analyzed for all or some of the following constituents —sodium, potassium, magnesium, iodine, chlorine, sulphate. An account is given of the methods used in processing the salt.

ACKNOWLEDGMENTS

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STRUCTURE AND BASEMENT TYPE FROM AEROMAGNETICS—CORREGIDOR, PHILIPPINES TO LABUAN, NORTH BORNEO

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TWO PLATES

The airborne magnetometer data presented in this paper were obtained in February, 1957, in flight from Corregidor, Philippines to Labuan, North Borneo, via Cape Calavite, Mindoro, Dumaran, and thence southwestward along the coast of Palawan. The overall length of this profile is slightly over 700 miles. Plate 1 shows the course of this profile.

The airborne magnetometer data were obtained using the Gulf Research and Development Company saturable core magnetometer, whose sensitive element was mounted in a trailed "bird." The recording sensitivity used for obtaining these data was 600 gamma full scale deflection. The data were obtained at 3,000 feet above sea level from Corregidor to Dumaran, and at 4,500 feet from Dumaran to Labuan.

GEOLOGY

For the purposes of the interpretation of airborne magnetometer or for surface magnetic surveys, it is of value to know the rock type outcrop, particularly of the igneous and metamorphic rocks. Furthermore, in sedimentary areas a knowledge of the expected type of igneous basement rocks is of value in correlating the type of magnetic anomaly to the rock types, although such information may be obtained from the magnetic anomalies.

Irving(3) has shown the general basement formation outcrops of the Philippines.

In progressing southwestward from the origin of the profile at Corregidor, the reported outcrops on Ambil and Gold islands are mapped as ultra-basic plutonites. To the west of these two islands, on Lubang Island, the outcrops are reportedly metamorphosed sediments, such as slates, quartzites and marbles. Continuing to the southwest, on the crossing of Cape Calavite to the Island of Mindoro, the mapped outcrops are undifferentiated

basement. Busuanga and Culion islands of the Calamian, are metamorphosed sediments. Southwestward, Dumaran Island shows metamorphosed sediments, and it is interesting to note that ultra-basic plutonites are mapped to the north of Puerto Princesa. In the northeast central part of Palawan a massive outcrop of granites and quartz monzonites is mapped, and undifferentiated basement in the southwest central core.

The major outcrops along the western shore of North Borneo are mainly Tertiary with a thin cover of Quarternary. Basement outcrops are mapped on the Island of Malawi which is located to the southeast of Bangi Island. In North Borneo, east of Jesselton, acid outcrops are mapped which are surrounded by intermediate and basic igneous rocks.

The course of this profile crossed a number of interesting structural features which have been reported upon by Alcaraz,(2) Irving,(3) and Teves.(6) The profile crosses the possible intersection of two fault lines, one of which is the northwest-southeast fault line down-thrown to the southwest along the west coast of Luzon, and the fault line, downthrown to the south, which is reported to lie along the north coast of Mindoro. These two faults are shown coalescing near the north coast of Mindoro. Continuing to the southward, the profile should cross the volcanic line, which extends to the northeast and southwest. Hence, within the first one hundred miles of this profile, an extremely complex regional fault and structural zone is crossed.

MAGNETICS

At the origin of the profile, at Corregidor, the inclination of the earth's total magnetic field is 15° to the north, and its intensity is approximately 40,500 gamma. At Dumaran Island, the inclination is 6° north, and the intensity of the earth's total magnetic field is approximately 39,800 gamma. At Mile 510 the inclination of the earth's magnetic field is 0°, and its intensity is 40,000 gamma. At Labuan, the inclination of the earth's total magnetic field is 6° south, and its intensity is about 40,300 gamma.

The observed total magnetic intensity variation from the start of the profile to approximately Mile 210, between Busuanga anad Dumaran islands, roughly parallel to the published value. However, from this point to approximately the latitude

of Puerto Princesa, the observed magnetic intensity deviates from the published value by over 100 gamma.

Continuing to the southwestward from Mile 350, the observed gradient of the earth's total magnetic field is approximately equal to the published value, excepting for local deviations.

The magnetic anomalies from the start of the profile at Corregidor southwestward to about Mile 75, which is off the south coast of Cape Calavite, show relatively violent deviations ranging in amplitude from 20 or 30 gamma to over 200 gamma. This zone of violent magnetic anomalies is on the approach to the Taal volcanic line. To the southwest from Cape Calavite, to about Mile 320, the magnetic anomalies are for the most part of low amplitude of 5 to 15 gamma, and are relatively broad. This would be indicative of a deep basement, and probably acidic in nature. However, superimposed on these broad low amplitude anomalies are sharper but low amplitude magnetic anomalies which would be indicative of possible shallow intrusives and/or extrusives.

From Mile 320 to approximately Mile 480, the magnetic anomalies range from broad anomalies with amplitudes of up to 100 gamma, to relatively sharp magnetic anomalies superimposed on broad magnetic anomalies, and these sharp, narrow anomalies have amplitudes of from 50 to 100 gamma. In this interval, the profile passes to the east of the mapped ultrabasic plutonites on the Island of Palawan. These relatively high amplitude magnetic anomalies would be due to a basic or intermediate type igneous intrusive.

Continuing to the southwestward from about 480, the anomalies are relatively broad ranging from widths of 40 to 80 miles to about Balambangan Island. These broad anomalies have amplitudes of 100 and 150 gamma, respectively. These broad features are believed to be sub-basement igneous complex anomalies.

The extremely sharp negative anomaly observed in the interval from Mile 560 to Mile 565, to the southwest of Balambangan Island, is probably caused by a local shallow basic intrusive.

From Mile 565 to the end of the profile, the magnetic anomalies are relatively gentle, and of low amplitude. This is indicative of the relatively uniform basement, and probably in the nature of an acid igneous rock.

BASEMENT STRUCTURE AND DEPTHS FROM AEROMAGNETICS

Depth determinations have been made along the length of this profile from the magnetic anomalies. In order to make these depth determinations simplifying assumptions had to be made as to the shapes of the anomalies, and the shape of the causes of the anomalies. These assumptions have been discussed by Agocs and Isaacs.(1) Naturally, using such simplifying assumptions, it would be expected that gross errors would arise in these depth determinations. However, from these analyses, a quantitative concept may be had as to the depth to cause of the anomalies, and structural determinations may be made. Therefore, it is felt that the analyses of these magnetic data have been justified. It permits the correlation of these quantitative data as well as the structural determinations therefrom with the geologic observations and extrapolations, rather than attempting to correlate geologic structural indications to magnetic features.

At the start of the profile, at Corregidor, the depth to basement is about 8,000 feet, and it rises to approximately sea level on the approach to Gold Island. At Gold Island ultrabasic plutonites outcrop, and the depth determinations made from the aeromagnetics have been verified. Continuing to the southwest, on the approach to Cape Calavite of the Island of Mindoro, the depth to the igneous horizon increases and off the shore of Cape Calavite, it approaches about 5,000 feet. In the interval from the south coast of Gold Island to south Cape Calavite, a second depth horizon is observed whose level ranges from 5,000 to 10,000 feet. It is possible that this deeper horizon may be the true igneous basement, whereas the shallower zone is interpreted as being due to the volcanics along the Taal volcanic line.

In the interval from Mile 85 to Mile 120 only two depth points could be obtained, due to the lack of magnetic anomalies probably because of the lack of magnetic contrast and the great depth to the source of the magnetic anomalies. It is found in this section that the depth to the igneous horizon is over 20,000 feet. As a result of the abrupt increase in depth to the igneous horizon from 10,000 to over 20,000 feet between Mile 70 and Mile 80, it is necessary to place a fault downthrown to the southwest in this interval. This fault zone may be the basement location of the faulting which has been

inferred to lie off the north coast of Mindoro, and west of the Island of Luzon. This interpretation is indicated since the fault trace is not observed on the north coast of Mindoro.

From Mile 130 to approximately Mile 210 an igneous horizon is found whose depth is approximately 4,000 feet sub-sea, but which rises to approximately 1,000 feet sub-sea level at Busuanga Island, where the outcrops are mapped as metamorphosed sediments. In addition, within this section a few depth points have been obtained at a level of about 10,000 feet subsurface. This would again indicate a dual horizon, one of which may be due to shallow volcanics, or intrusive horizons, and a deeper horizon, the basement at about 10,000 feet. As a result of discontinuity in the level at Mile 120, a fault is placed at this point, downthrown to the northeast.

The graben indicated at the combination of the faults at Mile 80 and at Mile 120 has been shown by Irving(4) as the Mindoro Reentrant. This zone may be the northeastward extension of the graben which is mapped off the northwest coast of Palawan Island.

In the interval from Mile 210 southwestward to the end of the profile, only a single igneous horizon is mapped, although there are a few erratic depth points. In view of the previous indications, it is believed unlikely that intrusives exist along this section.

Between Mile 210 and Mile 320 it was possible to make only three depth determinations. To the north of Dumaran Island, a depth of over 30,000 feet to the igneous horizon has been determined, and to the southwest of the island, the depth determinations show the igneous horizon to be at a depth of about 10,000 feet. This would indicate that Dumaran Island may be located near a major fault zone. The location of the trace of the southern fault of the possible graben cannot be fixed with any certainty, since there are no depth determinations for an interval of about 40 miles, and Dumaran Island lies in this section of indeterminateness.

From Mile 280 to Mile 320 the depth to the igneous horizon is about 10,000 feet, and then at Mile 330 the igneous horizon rises to about 5,000 feet sub-sea, indicating the possibility of a fault downthrown to the northeast between these two points. Continuing to the southwestward, the basement rises until it is approximately at sea level at Mile 400, which is

correlated with the sharp magnetic anomalies and the major magnetic low observed at this point. Continuing to the southwest from Mile 400, the depth to the igneous horizon increases to about 6,000 feet at Mile 425, and then rises to about 3,000 feet sub-sea at Mile 435 and continues at this level to about Mile 470.

At Mile 470 there is an abrupt discontinuity in depth, and the horizon is observed at 10,000 feet. This would force the placing of a fault between Mile 465 and 470, and the fault would be downthrown to the southwest.

From Mile 470 to Mile 520 the igneous horizon rises from 10,000 feet to about 3,000 feet sub-sea at this latter point, and then there was an abrupt increase to almost 10,000 feet at Mile 530, which would place a minor fault at this point.

Continuing to the southwest, the depth decreases on the approach to Balambangan Island, at which point it is about 3,000 feet, and off its south shore it rises to sea level, and then increases to about 6,000 feet to the south shore of Sikuati Island.

The depth to the igneous horizon may be well over 20,000 feet at Mile 600, to the southwest of Sikuati Island, and rises to about 16,000 feet at Mile 660 which is approximately at the latitude of Jesselton. At this point the depth to basement decreases abruptly so that it is about 1,000 feet, and then dips to the southwest, so that its depth at the end of the profile is about 6,000 feet at Labuan.

The data from a single profile are difficult to use to determine structural extensions. However, the result of this study shows that there is a fault zone, or a graben located to the south of Cape Calavite, of the Island of Mindoro. It is possible that the major fault located to the north of Dumaran Island, and the one located in the vicinity of Dumaran Island may be a single fault trace whose strike is approximately north 30° east, and the downthrown side being to the east. The second fault, to the southwest of Dumaran, approximately at the latitude of Honda Bay may be a minor relief fault. The fault which is observed at about Mile 525, downthrown to the southwest, may be a trace of a fault which extends to the south, separating Bangi Island from Malawali, on which latter ultra-basic plutonite outcrops are reported.

The fault observed to the south of Sikuati downthrown to the southwest, and the fault trace observed at about Mile 660,

downthrown to the northeast may be the evidence of a marginal fault, downthrown to the northwest which lies off the northwest shore of North Borneo, and continues to the northeast tie with the fault indicated off the northwest coast of Palawan. This would indicate a major deep off the shore of North Borneo between Jesselton to the south and Sikuati to the northeast.

CONCLUSIONS

The quantitative study of this aeromagnetic profile has confirmed the presence of a structural complexity in the vicinity of the northwestern part of Mindoro Island. In addition, it indicates the possibility of a northeast-southwest trending fault, downthrown to the east located at about Dumaran Island. Furthermore, this study indicates the possibility of the southwestward extension of the Palawan fault which is downthrown to the northwest, to the northwest shore of North Borneo. This latter would indicate the possible southwestward extension of the Palawan graben. However, data are not available to confirm this possibility, since the profile did not extend in a direction to cut the parallel fault located to the northwest.

It may be reasonable to expect that a regional airborne magnetometer survey of the territorial waters of the Philippines would resolve numerous geological problems and possibly aid in the economic development of the entire area. Such a survey could be made on flight line spacings of 10 to 20 miles using radio beacon positions and ground contact points for the mapping of the data. For the area of about 700,000 square miles, about 35,000 linear miles of aeromagnetic profiles could cover the area adequately, and further detail surveys could be made by groups interested in the commercial possibilities located by this reconnaissance aeromagnetic survey.

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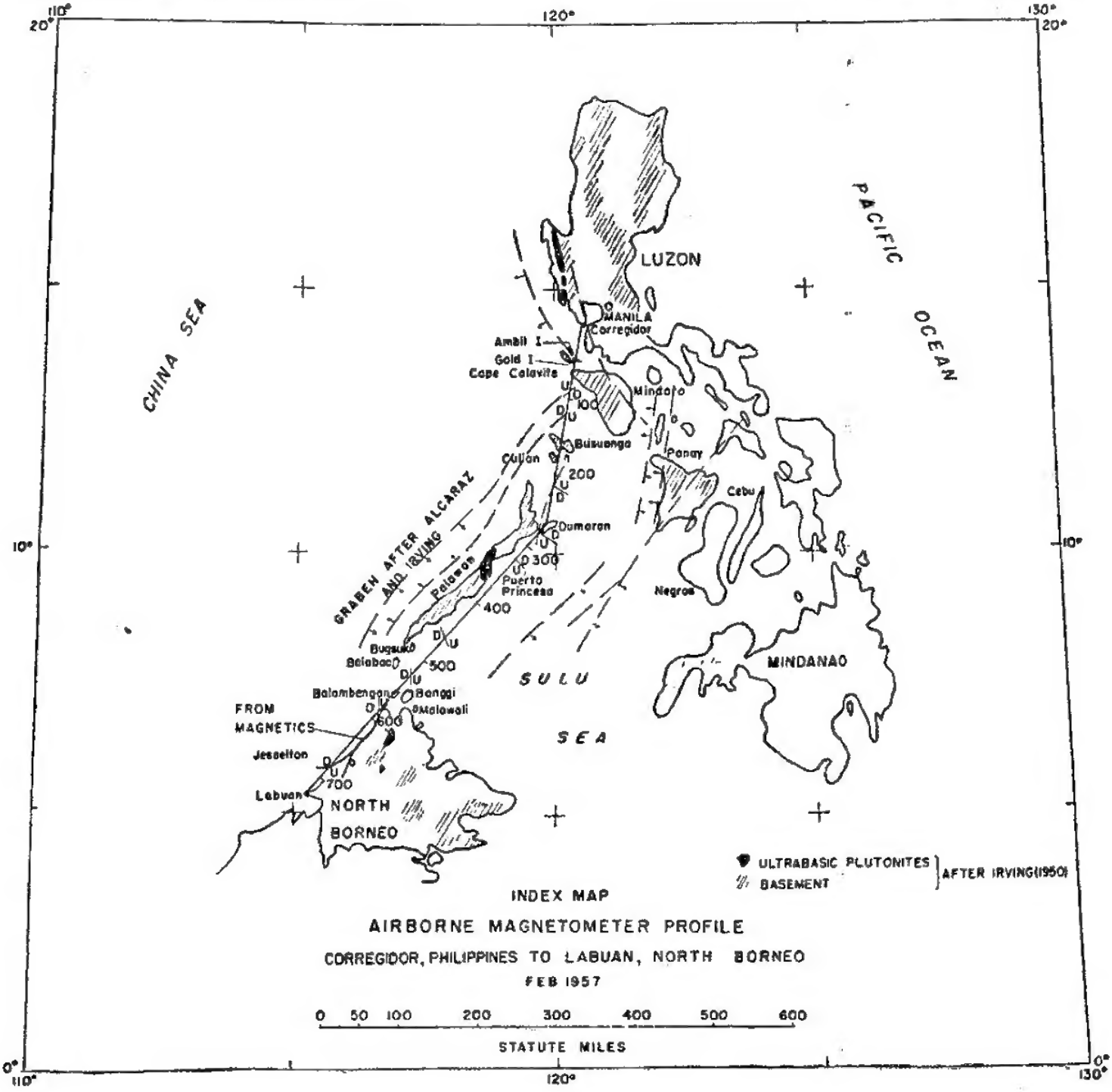
ILLUSTRATIONS


110°
120°
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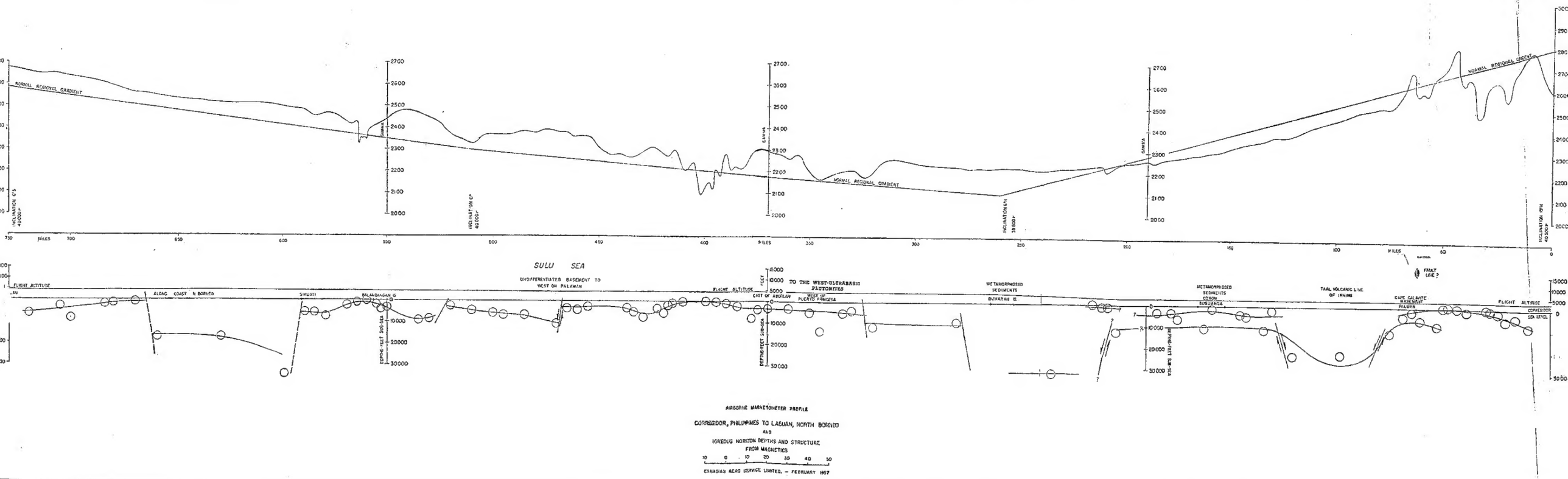
CHINA SEA
PACIFIC OCEAN
LUZON
MANILA
Corregidor
Ambil I.
Gold I.
Cape Calavite
Mindoro
Busuanga
Culion
Panay
Cebu
200
Dumaran
300
Puerto Princesa
Palawan
GRABEN AFTER ALCARAZ AND IRVING
Negros
400
Bugsuk
Balabac
500
MINDANAO
SULU
SEA
Balambengan
Banggi
Malawali
FROM MAGNETICS
600
Jesselton
700
Labuan
NORTH BORNEO
ULTRABASIC PLUTONITES
BASEMENT
AFTER IRVING(1950)
INDEX MAP
AIRBORNE MAGNETOMETER PROFILE
CORREGIDOR, PHILIPPINES TO LABUAN, NORTH BORNEO
FEB 1957
0 50 100 200 300 400 500 600
STATUTE MILES

PLATE 1.



AIRBORNE MAGNETOMETER PROFILE

CORREGIDOR, PHILIPPINES TO LABUAN, NORTH BORNEO

AND

IGNEOUS HORIZON DEPTHS AND STRUCTURE FROM MAGNETICS

10 0 10 20 30 40 50

CANADIAN AERO SERVICE LIMITED, — FEBRUARY 1957

Plate 2.

BOOKS

Books received from time to time by the Philippine Journal of Science are reviewed and acknowledged in this section.

New Birds from the Philippines. By A. L. Rand and D. S. Rabor. Fieldiana. Zoology (2) 42 (1957) 13-18. Published by Chicago Natural History Museum.

From the birds collected by D. S. Rabor, the following new Philippine birds are described:

1. *Ptilocichla mindanensis fortichi* ..... Bohol Island
2. *Stachyris nigrocapitata boholensis* .....do.....
3. *Ficedula hyperythra malindangensis* ..... Mt. Malindang, Mindanao
4. *Rhinomyias ruficauda boholensis* ..... Bohol Island
5. *Rhinomyias ruficauda zamboanga* ..... Mt. Malindang, Mindanao
6. *Pachycephala philippinensis siquijorensis* ..... Siquijor
7. *Sitta frontalis zamboanga* ..... Mt. Malindang, Mindanao
8. *Rhabdornis inornatus zamboanga* .....do.....
9. *Dicaeum anthonyi masawan* .....do.....
10. *Aethopyga boltoni malindangensis* .....do.....
11. *Arachnothera clarae malindangensis* .....do.....
12. *Hypocryptadius cinnamomeus malindangensis* .....do.....

51917——7

—C. G. M.